THE JOURNAL OF ENGINEERING EDUCATION

ublished by THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

EW SERIES
L. XXIV., NO. 10 | JUNE, 1934 | Subscription Price $3.00 per year
Single copies 50 cents

eady in June — *Fourth Edition*

BREED AND HOSMER'S

Higher Surveying

By CHARLES B. BREED and GEORGE L. HOSMER

Professor of Railway and Highway Transportation and Professor of Geodesy, respectively, at the Massachusetts Institute of Technology

In the present edition Chapters I, II, and III have been rewritten and much new material added. Chapter I contains new matter on triangulation instruments and methods, on curvature and refraction problems, more complete formulas for base-line work, on calculation of triangulation, and on rectangular coördinate systems. Most of these changes have been made necessary by recent changes in geodetic practice. Chapter II (Astronomy) has been given a more general treatment, better suited to class use, and includes more of the general field methods of observation than it did formerly. The matter of interpolation has been made to accord with the latest edition of the American Ephemeris. Precise leveling in Chapter III has been rewritten and a description of the Paulin barometers has been added to the chapter. Aerial Surveying has recently made such strides that revision of the text became a necessity. Chapters VI and XII have therefore been rewritten and much new matter added.

Approximately 599 pages — 5 by 7½ — Probable price, $3.50

ohn Wiley & Sons, Inc. — **440 Fourth Ave., New York**

2d Annual Meeting, Cornell University, Ithaca, N. Y.

Conferences: Tuesday, June 19, to Thursday noon, June 21
egular Meetings: Thursday noon, June 21, to Saturday noon, June 23

AMERICA LEADS IN TELEPHONE SERVICE

THE telephone was invented in this country and it has reached its highest development here. There are six times as many telephones in relation to population in the United States as in Europe and the service is better.

This high efficiency did not just happen. It is the result of American initiative and a sincere desire to serve the public. Back of it all you see the value of the structure and the fundamental policies of the Bell System.

This system functions in the best interests of the telephone user because it combines and unifies the essentials of efficient telephone communication — research, engineering, manufacture, supply and operation. There is no waste through an overlapping of activities. Everything is co-ordinated to give you the best telephone service at the lowest possible cost.

The general plan of the Bell System is the cumulation of more than fifty years' experience, resulting in one policy, one system and universal service.

BELL TELEPHONE SYSTEM

THE JOURNAL OF ENGINEERING EDUCATION

Published by the Society for the Promotion of Engineering Education

Published under the Supervision of the Publication Committee.
W. E. Wickenden, R. A. Seaton, F. L. Bishop, Editor, University of Pittsburgh.
Published at Prince and Lemon Sts., Lancaster, Pa.

Entered as second-class matter at the Post Office at Lancaster, Pa., under the Act of March 3, 1870.

New Series
Vol. XXIV, No. 10. JUNE, 1934 Subscription Price, $3.00 per year. Single Copies, 50 cents.

TABLE OF CONTENTS

Program, 42d Annual Meeting at Cornell University 641
S.P.E.E. Meeting at Cornell University 665
A Course in Advanced Shop Practice as Taught at the University of Michigan. A. P. Gwiazdowski 668
Preface to Vol. II, Investigation of Engineering Education 682
Training for Citizenship. Roy V. Wright 686
The Economic Sequence in the Civil Engineering Curriculum. J. K. Finch 690
Increasing the Curriculum. John Younger 697
Undergraduate Research in Engineering. R. C. Ernst 698
T-Square Page 704
College Notes 705
Sections and Branches 708
Book Reviews 717

HEADQUARTERS OF THE SOCIETY

UNIVERSITY OF PITTSBURGH, PITTSBURGH, PA.

OFFICERS OF THE SOCIETY, 1933–34

President

W. E. WICKENDEN, Case School of Applied Science, Cleveland, Ohio

Vice-Presidents

F. V. LARKIN, Lehigh University, Bethlehem, Pa.
B. M. BRIGMAN, University of Louisville, Louisville, Ky.

Secretary

F. L. BISHOP, University of Pittsburgh, Pittsburgh, Pa.

Treasurer

W. O. WILEY, John Wiley & Sons, New York City

Assistant Secretary

NELL MCKENRY, University of Pittsburgh, Pittsburgh, Pa.

BOARD OF INVESTIGATION AND COORDINATION

BISHOP, F. L., *Secretary,* University of Pittsburgh, Pittsburgh, Pa.
JACKSON, D. C., Massachusetts Institute of Technology, Cambridge, Mass.
KIMBALL, D. S., Cornell University, Ithaca, N. Y.
SACKETT, R. L., Pennsylvania State College, State College, Pa.
SCOTT, CHAS. F., *Chairman,* Yale University, New Haven, Conn.
TURNEAURE, F. E., University of Wisconsin, Madison, Wis.
WICKENDEN, W. E., *President,* Case School of Applied Science, Cleveland, Ohio

---

HAMMOND, H. P., Director of S. P. E. E. Summer School, 99 Livingston Street, Brooklyn, N. Y.

PROGRAM*

OF THE

FORTY-SECOND ANNUAL MEETING

OF THE

SOCIETY FOR THE PROMOTION

OF

ENGINEERING EDUCATION

Time Schedule 642
General Sessions 644
Conferences 646
Headquarters 660
Housing 660
Officers 661
Committees 661

Conferences:

Chemical Engineering Unit Operations Teaching 646
Civil Engineering 648
Coöperative Engineering Education 648
Deans and Administrative Officers .....
Drawing 649
Electrical Engineering .....
Electronics and Electrical Communications 650
Engineering Economy 650
Engineering Research 650
English 651
Fluid Mechanics 651
Heat Transfer 652
Industrial Engineering .....
Junior Colleges 653
Laboratory Procedure in Teaching Machine Production 654
Machine Design 655
Mathematics 655
Mechanical Engineering 656
Pre-College Guidance and the Orientation of Freshmen 656
Technical Institutes 657
Use of Models in Laboratory Teaching of Structures and Hydraulics 658

CORNELL UNIVERSITY

ITHACA, N. Y.

Conferences: Tuesday, June 19, to Thursday noon, June 21
General Sessions: Thursday noon, June 21, to Saturday noon, June 23, 1934

* This is the program as of June 1st. Additions and corrections will appear on the program distributed at time of registration at the meeting.

TIME SCHEDULE

TUESDAY	MEETING	LOCATION
9:00 A.M.	Electronics and Electrical Communication	
	Heat Transfer	
	Laboratory Uses of Models in Structures and Hydraulics	
2:00 P.M.	Chemical Engineering Unit Operations Teaching	
	Drawing and Descriptive Geometry	
	Electronics and Electrical Communication	
	English	
	Fluid Mechanics	
	Heat Transfer	
	Junior Colleges	
	Laboratory Uses of Models in Structures and Hydraulics	
	Mathematics	
	Pre-College Guidance and Freshman Orientation	
7:00 P.M.	Dinner Meeting, Council	Willard Straight Hall
	Dinner Meeting, Wives of Council	Willard Straight Hall
8:00 P.M.	Joint Session: Fluid Mechanics, Heat Transfer, Chemical Engineering	
WEDNESDAY		
9:00 A.M.	Chemical Engineering Unit Operations Teaching	
	Coöperative Plan of Education	
	Drawing and Descriptive Geometry	
	Electronics and Electrical Communication	
	English	
	Fluid Mechanics	
	Heat Transfer	
	Junior Colleges	
	Laboratory Procedure in Teaching Machine Production	2 W. Sibley Hall
	Laboratory Uses of Models in Structures and Hydraulics	
	Mathematics	
	Mechanical Engineering	
	Pre-College Guidance and Freshman Orientation	
1:00 P.M.	Luncheon Meeting, Members of Southeast	Willard Straight Hall
2:00 P.M.	Chemical Engineering Unit Operations Teaching	
	Civil Engineering	
	Coöperative Plan of Education	

	Drawing and Descriptive Geometry	
	Electronics and Electrical Communication	
	Electrical Engineering	
	English	
	Fluid Mechanics and Heat Transfer	
	Industrial Engineering	
	Junior Colleges	
	Laboratory Procedure in Teaching Machine Production	2 W. Sibley Hall
	Laboratory Uses of Models in Structures and Hydraulics	
	Mathematics	
	Mechanical Engineering	
	Pre-College Guidance and Freshman Orientation	
4:30 P.M.	Reception and Tea	Willard Straight Hall
6:30 P.M.	Junior College Dinner	
8:00 P.M.	Technical Institutes	

THURSDAY

9:00 A.M.	Chemical Engineering Unit Operations Teaching	
	Coöperative Plan of Education	
	Drawing and Descriptive Geometry and English	
	Electronics and Electrical Communication	
	Engineering Economy	
	Engineering Research	
	Fluid Mechanics	
	Junior Colleges	
	Laboratory Procedure in Teaching Machine Production	2 W. Sibley Hall
	Laboratory Uses of Models in Structures and Hydraulics	
	Machine Design	
	Pre-College Guidance and Freshman Orientation	
	Technical Institutes	
12 M.	Luncheon, Teachers of Mechanics	
2:00 P.M.	General Session	Baker Hall
4:00 P.M.	Tour of State Parks	Starting Point, Willard Straight Hall
6:00 P.M.	Dinner, Division of Drawing	
8:30 P.M.	Informal get-together	Willard Straight Hall

FRIDAY

9:00 A.M.	General Session	Baker Hall
2:00 P.M.	General Session	Baker Hall
7:00 P.M.	Annual Dinner	Willard Straight Hall

SATURDAY

9:00 A.M.	General Session	Baker Hall
12 M.	Adjournment	

PROGRAM

GENERAL SESSIONS

THURSDAY

P.M.

2:00 Opening general session, Baker Hall, W. E. Wickenden, President of the Society, presiding.

Address of Welcome. Albert Russell Mann, Provost, Cornell University

"Reconciling the Professional and General Objectives of Engineering Education."

Presidential Address: Discipline and Discipleship. W. E. Wickenden, President, Case School of Applied Science.

Are Engineering Schools Primarily Technical Schools? Harvey N. Davis, Stevens Institute of Technology.

Readjustment of Purpose and Program in Engineering Education. R. E. Doherty, Yale University.

The Liberal Pursuit of Engineering Studies. Gordon M. Fair, Harvard University.

Report of Treasurer, W. O. Wiley.

Report of Secretary, F. L. Bishop.

4:00 Tour of State Parks.

6:00 Special group dinners.

8:30 Informal social get-together in Memorial Hall of Willard Straight Hall.

FRIDAY	MEETING	LOCATION
A.M.		
9:00	Symposium: Marketing the Graduate's Services Discussion led by W. A. Shoudy, Columbia University S. S. Board, Yale Graduates' Placement Bureau A. D. Moore, University of Michigan G. M. Butler, University of Arizona S. B. Earle, Clemson College F. C. Bolton, Texas A. & M. College Are There Too Many Engineers? Pennsylvania State College Committee	Baker Hall
P.M.		
2:00	Report of Chairman, Board of Investigation and Coördination, Charles F. Scott, Yale University Report on Projects Reports of Committees: Length of Curriculum. R. E. Doherty, Chairman Degrees. O. M. Leland, Chairman Graduate Studies. H. P. Hammond, Chairman Summer Schools. R. A. Seaton, Chairman Honors Group. R. H. Frazier, Massachusetts Institute of Technology	

Industrial Engineering Curriculum. P. T. Norton, Jr., Virginia Polytechnic Institute

7:00 Annual Dinner, Willard Straight Hall, President W. E. Wickenden, presiding
Election of Officers
Presentation of Lamme Medal
Address: F. P. Keppel, Carnegie Corporation

SATURDAY

A.M.

9:00 General Session — Baker Hall
"Professional Recognition and Educational Standards"
Engineers' Council for Professional Development. C. F. Hirshfeld, Detroit Edison Company
Educational Background of Certain Distinguished Engineers. C. Frank Allen, Massachusetts Institute of Technology
Instructional Standards. H. S. Rogers, Brooklyn Polytechnic Institute
Adjournment

CONFERENCES

CHEMICAL ENGINEERING UNIT OPERATIONS TEACHING

F. C. VILBRANDT, *Chairman*

Tuesday

2:00 P.M. 1. Resume of Chemical Engineering Education in Colleges and Universities.
a. Schools
b. Enrollment—Undergraduate; Graduate
c. Teachers
d. Facilities
e. Degrees
f. Courses in Chemical Engineering

Speaker: F. C. Vilbrandt, Iowa State College. Time 10 min.

No discussion—Introductory statistical paper. (Mimeographed)

2. Chemical Engineering Courses. Sources of Material.
a. Contributions of Chemistry
Physics
Mathematics
Economics
English
and Engineering courses to Chemical Engineering Unit Operation courses.

Speaker: J. C. Elgin, Princeton University. Time 10 min.

b. Curricular placement and relationship of Chemical Engineering Unit Operation courses to the above basic courses.

Speaker: J. H. James, Carnegie Inst. of Tech. Time 10 min.

c. Critical Evaluation of above courses to Chemical Engineering and curricular placement of Chemical Engineering courses.

Leader: J. C. Elgin.

Clinic—2 min. per speaker; open to all; total elapsed time 30 min.

8:00 P.M. Joint Seminar.

Seminar on Fluid Mechanics. H. L. Mason, Columbia University. Chairman.

Application of Fluid Mechanics to Mechanical, Aeronautical, Chemical, Civil, and Naval Engineering.

Wednesday

9:00 A.M. 1. Teacher Preparation and Opportunities for Advancement.
a. Methods and Facilities.
b. Points of view of administrations.

Leader: .....

Clinic—2 min. per speaker; open to all; total elapsed time 30 min.

2. Lectures, Organization and Presentation. How

Do You Handle Lectures? (Come prepared with 5-min. papers on present practice, to be turned into the secretary.)

a. Text books.
b. References and collateral reading.
c. Mimeographed material.
d. Professional experience of teachers and students.
e. Written and oral quizzing.
f. Physical aids. Lantern slides; manufacturers' material, etc.
g. Inspection trip.
h. Outside speakers.

Leader: .....

Clinic—5 min. per speaker, open to all; total elapsed time 1 hr. and 15 min.

3. Seminars or technical lectures. (Come prepared for 2-min. papers to be turned in.)

Leader: .....

Clinic—2 min. per speaker, open to all; total elapsed time, 45 min.

2:00 P.M. Combined with Heat Transfer Seminar under the direction of F. C. Stewart.

1. Dimensional Analysis. J. F. D. Smith, Harvard University.
2. Effect of Heat Transfer on Flow of Fluids. T. B. Drew, Massachusetts Institute of Technology.
3. Economics of Fluid Mechanics and Heat Transfer. W. J. Wohlenberg, Yale University.

Discussion.

Thursday, June 21

9:00 A.M. 1. Laboratory Equipment.

Presentation of 3-min. papers on present practice; papers to be turned in to the secretary.

a. Description: Size and type; quantity of material required to operate.
b. Value or need.
1. Principles
2. Measurements
3. Operating Technique
4. Design
c. Feasibility.

Speaker: .....

Clinic—3 min. per speaker, open to all; total elapsed time, 30 min.

2. Administration of Laboratory Work.

a. Squad teaching. Time 5 min.
Speaker, H. A. Webber, Iowa State University.
Discussion: 10 min.

b. Demonstration Teaching. Time 5 min.
Speaker, L. A. Stout, Washington University.
Discussion: 10 min.

c. Coöperative or Industrial Contracting. Time 5 min.
Speaker, R. S. Tour, University of Cincinnati.
Discussion: 10 min.

d. Comprehensive Problems. Time 5 min.
Speaker, A. O. Hougen, University of Wisconsin.
Discussion: 10 min.

3. Laboratory Note Books and Texts. Time 5 min.
Speaker, S. G. Ogburn, Bucknell University.
Discussion: 10 min.

4. Research Possibilities for Laboratories.
a. Present Facilities and Faculties. Time 5 min.
Speaker, B. F. Dodge, Yale University.
Discussion: 10 min.
b. Possible Opportunities for Research Work. Funds and Equipment.
1. Industrial Fellowship
2. Experiment Stations
3. Senior Problems

Clinic—2 min. per speaker, open to all; total elapsed time, 30 min.

5. Industrial Contacting and Collaboration.
Presentation of 2-min. papers on present practice.
a. Industrial Fellowships.
b. Coöperative System.
c. Personnel Work. Placement.
d. Professional Consultation Work.

Leader: .....
Clinic—2 min. per speaker, open to all; total elapsed time, 30 min.

All leaders will be selected at the time of the seminar.

CIVIL ENGINEERING

L. E. CONRAD, Kansas State College, *Chairman*

Wednesday

2:00 P.M. Economic Phases of Highway Engineering in Undergraduate Civil Engineering Courses. T. R. Agg, Iowa State College; R. A. Moyer, Iowa State College

COÖPERATIVE PLAN OF EDUCATION

J. E. MCDANIEL, Georgia School of Technology, *Chairman*

Wednesday

2:00 P.M. Coöperative Course as Compared with Four-Year Commerce Curriculum. P. Evans Coleman.

Thursday

9:00 A.M. Evaluation of Coöperative Academic Credits. A. R. Cullimore, Newark College of Engineering.

DRAWING AND DESCRIPTIVE GEOMETRY

H. M. McCULLY, Carnegie Institute of Technology, *Chairman*

Wednesday

9:00 A.M. Design and Appearance. O. M. Stone, Case School of Applied Science.

Discussion: M. Donald Dohner, Westinghouse E. & M. Company.

Nomography. J. N. Arnold, Purdue University.

Experimental Mapping of Potential Fields Satisfying the LaPlacian Equation. M. S. Schonvizner and John Boyd, Westinghouse E. & M. Co.

Shop Practices and Processes. Herman C. Hesse, University of Virginia.

Symposium: Motivating Engineering Drawing and Descriptive Geometry for Freshman Engineering Students. Participated in by all members of the division.

2:00 P.M. Place of the Engineering Drafting Room in the Future Recruitment Program of Engineering Organizations. T. G. Crawford, General Electric Company, and Thos. E. French, Ohio State University.

Value of Blue Print Reading Courses in the Preparation of Technical Students. A. C. Jewett, Carnegie Institute of Technology.

Drawing Courses for Chemical Engineering Students. Ralph S. Paffenbarger, Ohio State University; Wm. M. McConnell, Carnegie Institute of Technology.

Graphical Presentation of Course Content. F. G. Higbee, Iowa State University.

Visual Methods for Presenting Mechanical Drawing. Justus Rising, Purdue University.

Thursday

Joint Meeting with the Division of English, MISS SADA HARBARGER, *Chairman*

9:00 A.M. Practical Methods of Coöperating in Drawing and English.

Methods of Becoming Informed on the Work of Each Department, that is, English Teacher Knowing more About the Objectives of Courses in Drawing, and Drawing Teacher Knowing more About the Objectives of English Courses in an Attempt to Discover Common Objectives.

The Relative Importance to an Engineer of Drawing and English as Methods of Expression in the First Five Years of his Professional Career. C. S. Coler, Westinghouse E. & M. Co.

6:00 P.M. Dinner meeting. (Tickets may be purchased at time of registration.)

The Historical Displays.

Drawing Instruments.

1. F. W. Ming, Brooklyn Polytechnic Institute.
2. The Collection of Old Drawings—William Griswold Smith, Northwestern University.
3. Historical Textbooks—Francis M. Porter, University of Illinois.

Slide Rule Practice as an Interest Factor in Engineering Drawing, H. M. McCully.

Announcements of the Judges in the Divisional Competition and awarding of shingles.
Business meeting.

ELECTRONICS AND ELECTRICAL COMMUNICATIONS

W. L. Everitt, The Ohio State University, *Chairman*

Tuesday

9:00 A.M. Symposium on Graduate Work. Edward Bennett, University of Wisconsin.

2:00 P.M. Relation of the Communication Field to the Electrical Engineering Curriculum. M. P. Weinbach, University of Missouri.

Selection and Development of Teachers for Communication Engineering Instruction. O. W. Eshbach, American T. & T. Co.

Wednesday

9:00 A.M. Symposium on Course Content. H. R. Minno, Harvard University.

2:00 P.M. Sources of Material for the Development of Subject Matter in Electronics and Communication Engineering. H. E. Hartig, University of Minnesota.

The Application of Communication Techniques to Fields Other Than Electrical Engineering. E. B. Kurtz, University of Iowa.

Thursday

9:00 A.M. Symposium on Laboratory Equipment and Practice. H. H. Newell, Worcester Polytechnic Institute.

ENGINEERING ECONOMY

Sponsored by Committees on Civil, Electrical, Industrial and Mechanical Engineering

Thursday

9:00 A.M. Contributions from the Field of Industrial Engineering to the Teaching of Engineering Economy. P. T. Norton, Jr., Virginia Polytechnic Institute.

ENGINEERING RESEARCH

C. Francis Harding, Purdue University, *Chairman*

Thursday

9:00 A.M. Student Research and the Four-Year Engineering Curriculum. T. H. Morgan, Worcester Polytechnic Institute.

Development in Coöperative Research Conferences. J. W. Barker, Columbia University.

Coöperative Research at Purdue University. A. A. Potter, Purdue University.

The National Research Council since Corvallis. Maurice Holland, Director.

Coöperative Automotive Research. C. B. Veal, Society of Automotive Engineers.

ENGLISH

SADA A. HARBARGER, The Ohio State University, *Chairman*

Clinical Studies on the Demands for English in Actual Practice and the Effectiveness of English Courses for Engineering Students

Tuesday

2:00 P.M. Methods of Carrying on Training of Formal English Courses in Subsequent Technical College Courses. W. O. Birk, University of Colorado.
Interdepartmental Coöperation. W. O. Birk.
Extra-Curricular Methods, and Professional Society Student Papers for Stimulating Interest in English. W. F. Scammon, University of Maine.
Developing a Qualifying Standard for Composition. J. H. McKee, Purdue University.
Discussion.

Wednesday

9:00 A.M. Oral Expression: Demands, Extent, Type and Place of Public Speaking Courses in Engineering Curricula, Extra-Curricular Practice. Leader, C. F. De La Barre, Virginia Polytechnic Institute.
The Success of the Practical Application of Formal English Training after Graduation. Leader J. L. Vaughan, University of Virginia.

Thursday

9:00 A.M. Joint Meeting with the Division of Drawing.
6:00 P.M. English Group Dinner.

FLUID MECHANICS

H. L. MASON, Columbia University, *Chairman*

Tuesday

2–4 P.M. Industrial View of Hydraulics Instruction. C. F. Merriam, Pennsylvania Water & Power Co.
Scope of Fluid Mechanics Course. M. J. Thompson, University of Michigan.
Prerequisite Courses. R. W. Powell, Ohio State University.
Relation to Mechanical Engineering Courses. A. H. Blaisdell, Carnegie Institute of Technology.
Relation to Hydraulics Courses. S. B. Lilly, Swarthmore College.

8–10 P.M. Joint Session—Chemical Engineering, Heat Transfer, and Fluid Mechanics Groups.
Chemical Engineering Applications of Fluid Mechanics. J. H. Koffult, Ohio State University.
Hydrodynamics in Lubrication. A. E. Norton, Harvard University.
The Hydrocal. A. D. Moore, University of Michigan.

Wednesday

9–12 A.M. Current Programs of Research. W. E. Howland, Purdue University.
Selected Reading List. K. G. Merriam, Worcester Polytechnic Institute.

Visualizing Flow Phenomena. P. E. Hemke, Case School of Applied Science.
Exhibit of Demonstration Devices. F. G. Switzer, Cornell University, and R. A. Dodge, University of Michigan.

2–4 P.M. Joint Session—Heat Transfer and Fluid Mechanics.
Dimensional Analysis. J. F. Smith, Harvard University.
Effect of Heat Transfer on Flow of Fluids. T. B. Drew, Massachusetts Institute of Technology.
Economics of Fluid Mechanics and Heat Transfer. P. D. Close, Celotex Co.

Thursday

9–12 A.M. Aeronautical Engineering Applications of Fluid Mechanics. Th. Troller, Guggenheim Airship Institute.
Civil Engineering Applications of Fluid Mechanics. L. G. Straub, University of Minnesota.

HEAT TRANSFER

F. C. Stewart, Pennsylvania State College, *Chairman*

Tuesday

9:00 A.M. 1. Place and Scope of Heat Transfer Courses for Undergraduate and Graduate Students in (nature of problems):
a. Chemical Engineering. 10 min. A. O. Hougen, University of Wisconsin.
b. Mechanical Engineering. 10 min. E. O. Ellenwood, Cornell University.
c. Electrical Engineering. 10 min. A. D. Moore, University of Michigan.
d. Architectural and Civil Engineering. 10 min.
. . . . . .
Discussion. Open to all. 25 min.
3 min. written papers on the above topic from various schools or oral discussion from the floor.
2. Methods of Teaching Heat Transfer, Theory and Laboratory. Wm. H. McAdams, Massachusetts Institute of Technology.
Discussion: How Do Others Organize and Present Heat Transfer Instruction?

2:00 P.M. 1. Thermal Radiation—Methods of Investigation and Industrial Applications. R. H. Heilman, Mellon Institute.
2. Thermal Radiation—Subject Matter and Laboratory Technique. H. C. Hottel, Massachusetts Institute of Technology.
3. Conduction—Subject Matter and Laboratory Technique. F. B. Rowley, University of Minnesota.
4. Convection (Natural and Forced)—Subject Matter and Laboratory Technique. Wm. H. McAdams and T. B. Drew, Massachusetts Institute of Technology.
5. Discussion. 1 hour. Written discussion preferable.

8:00 P.M. Joint Seminar. Application of Fluid Mechanics to Mechanical, Aeronautical, Chemical, Civil, and Naval Engineering; Fluid Mechanics Division.
"The Hydrocal." A New Hydrodynamic Instrument for Solving Heat Transfer and Temperature Rise Problems. A. D. Moore, University of Michigan.

Wednesday

9:00 A.M.
1. Heat Transfer and the Phenomena of Evaporation. W. L. Badger, University of Michigan.
2. Heat Transfer and the Phenomena of Condensation of Pure Condensable Vapors. Herman Diederichs, Cornell University.
3. Heat Transfer and the Phenomena of Condensation of a Mixture of Condensable and Non-Condensable Gases. A. P. Colburn, E. I. duPont de Nemours.
4. Organization of a Course in Heat Transfer. E. C. Rack, Johns-Manville Company.
5. What Knowledge of Heat Transfer Does Industry Expect of College Graduates in Mechanical and Electrical Engineering? W. J. King and W. L. Knaus, General Electric Company.

Discussion.

2:00 P.M. Joint Session—Fluid Mechanics.
1. Dimensional Analysis. J. F. D. Smith, Harvard University.
2. Effect of Heat Transfer on Flow of Fluids. T. B. Drew, Massachusetts Institute of Technology.
3. Economics of Fluid Mechanics and Heat Transfer. W. J. Wohlenberg, Yale University.

Discussion.

JUNIOR COLLEGES

R. A. White, Grand Rapids Junior College, *Chairman*

Tuesday

2:00 P.M. A Joint Meeting with the Division of Drawing and the Divison on Freshman Guidance and Orientation.
Speakers: Ira M. Smith, University of Michigan; Clair V. Mann, Missouri School of Mines; Johnson O'Conner, Stevens Institute of Technology; W. R. Dumble, Ohio State University.

Wednesday

9:00 A.M. Semi-Professional Engineering Courses. R. H. Walters, Los Angeles Junior College.
Discussion.
Outline of General Engineering Courses for the Small Junior College. C. A. Anderson, Johnstown Junior College of the University of Pittsburgh.
Discussion.
The Engineering Department in the Junior College, Its Organization and Relation to the Other Departments of the College. A. R. Carr, Wayne University.
Discussion.

Relation of the Junior College to the Senior College. R. A. White, Grand Rapids Junior College.

2:00 P.M. The Future of Engineering Education in Junior Colleges. F. C. Bolton, Texas A. and M. College.
Discussion.
Engineering Courses in the Junior Colleges Viewed from the Technical Institute. W. B. Russell, Franklin Union.
Educational Requirements for Engineering Teachers in Junior Colleges. F. O. Rose, Modesto Junior College.
Discussion.
Open Discussion to Formulate Future Activities of the Junior College Division.

6:30 P.M. Junior College Dinner.
Experiences with Junior Colleges in Michigan. A. H. Lovell, University of Michigan.
Home-made Apparatus for Materials-Testing Laboratories. Demonstrations and Illustrations. Franklin Everett, University of Michigan.

Thursday

9:00 A.M. A Joint Meeting with the Division on Freshman Guidance and Orientation.
Engineering Courses Aiding in Orientation: Drawing, Surveying, Shop.
General Engineering Departments and Engineering. Problem Courses. Modified Science Courses, Chemistry, Mathematics.

LABORATORY PROCEDURE IN TEACHING MACHINE PRODUCTION

RALPH M. BARNES, State University of Iowa, *Chairman*

Room 2, West Sibley Hall

Wednesday

9:00 A.M. Outline of the Plan of the Conference. Ralph M. Barnes, University of Iowa.
Subject: Laboratory Procedure in Teaching Machine Production: a consideration of the aims and purposes, and of the value and costs of this work;—its place and relations in the curriculum.
Leader: Carl H. Casberg, University of Illinois.
Discussion by—R. W. Lindley, Purdue University; J. R. Connelly, Lehigh University; R. L. Sweigert, Georgia School of Technology.

12:00 M. Luncheon: Willard Straight Hall.

Room 2, West Sibley Hall

2:00 P.M. Subject: Laboratory Procedure (continued). Organization of subject matter and methods of presentation. Consideration of the "Factory Project" and of specific experiments using machine tools, etc., in this work.
Leader: A. P. Gwiazdowski, University of Michigan.
Discussion by—J. B. Finnegan, Armour Institute of Technology; C. E. Bullinger, Pennsylvania State College; E. S. Ault, Case School of Applied Science.

6:30 P.M. Dinner: Willard Straight Hall.
Following the dinner opportunity will be afforded for small groups to discuss specific problems in connection with teaching machine production.

Room 2, West Sibley Hall

Thursday

9:00 A.M. Subject: The Place of the Laboratory in the Study of the Relationship of the Industrial Worker to the Tools and Machines Which he Uses;—time and motion study, etc.
Leader: J. O. P. Hummel, Pennsylvania State College.
Discussion by—Dexter S. Kimball, Jr., Cornell University; Earl D. Hay, University of Kansas; G. J. Stegemerten, Westinghouse E. & M. Company.

MACHINE DESIGN

F. L. EIDMANN, Columbia University, *Chairman*

Thursday

9:00 A.M. Measurement of Requisite Abilities for Some Courses in Machine Design. J. R. Connelly, Lehigh University.
Discussion led by J. H. Billings, Drexel Institute.
Advanced Courses in Machine Design. E. S. Ault, Case School of Applied Science.
Discussion led by W. V. Dunkin, Georgia School of Technology.

MATHEMATICS

R. S. BURINGTON, Case School of Applied Science, *Chairman*

Tuesday

2:00 P.M. Purpose of Mathematical Conference. R. S. Burington, Case School of Applied Science.
Sequence of Mathematics Courses for Undergraduate and Graduate Engineering Students. I. S. Sokolnikoff, University of Wisconsin.
Qualifications and Training of a Teacher of Mathematics to Engineers. J. H. Weaver, The Ohio State University.
Contribution of Mathematics to Research in Fluid Motion and its Significance from an Educational Standpoint. Theodore Theodorsen, N.A.C.A., Langley Field, Va.
Discussion.

Wednesday

9:30 A.M. Increasing Use of Mathematics in Engineering Science. J. B. Scarborough, U. S. Naval Academy.
Type of Mathematics Training Needed by Electrical Engineers. A. M. Dudley, Westinghouse E. & M. Co.
Contribution of Mathematics to Research in Automotive Engineering. W. R. Griswold, Packard Motor Car Company.

Contribution of Mathematics to Research in Physics and Chemistry. S. Dushman, General Electric Company.
Place of Various Advanced Mathematics Courses in Engineering Curricula. J. B. Reynolds, Lehigh University.
Discussion.

12 M. Informal Luncheon.

2:00 P.M. Significant Research Work in Mathematics for Engineering Staff and Students. P. L. Alger, General Electric Company.
Contact of Mathematicians in a Consulting Capacity with Industry. A. A. Bennett, Brown University.
Coöperation between Mathematics Departments. E. J. Moulton, Northwestern University.
Plea for Pure Mathematics. Philip Franklin, Massachusetts Institute of Technology.
Discussion.

MECHANICAL ENGINEERING

B. G. Elliott, University of Wisconsin, *Chairman*

Wednesday

9:00 A.M. Liberalizing the Mechanical Engineering Course. F. L. Eidmann, Columbia University.

PRE-COLLEGE GUIDANCE AND ORIENTATION OF FRESHMEN

Tuesday

2:00 P.M. 1. Pre-College Guidance.
(a) In High Schools. Ira M. Smith, Registrar, University of Michigan.
General discussion.
(b) Aptitude Tests. Clair V. Mann, Missouri School of Mines.
General discussion.
(c) Freshman Week.
General discussion.

Wednesday

9:00 A.M. 2. Freshman Orientation.
(a) Counselor System. L. O. Stewart, Iowa State College.
Discussion led by A. H. Edgerton, University of Wisconsin.
(b) Orientation Lectures. Justus Rising, Purdue University.
(c) Need for Freshman Guidance. A. S. Langsdorf, Washington University.
(d) Personnel Departments. W. S. Evans, University of Maine; A. D. Hinckley, Columbia University.
General discussion.

2:00 P.M. Continuing the Discussion of Orientation.
(e) Psychological Clinics. Maurice E. Troyer, Ohio State University; Glen U. Cleeton, Carnegie Institute of Technology.
(f) Improper Orientation as a Factor in Failure and Its Effect on the Worker. C. S. Coler, Westinghouse E. & M. Co.

(g) To What Extent can Guidance Compensate for Lack of Native Ability? H. S. Rogers, Brooklyn Polytechnic Institute.

Thursday

9:00 A.M. 3. The Freshman Curricula.
(a) Engineering Courses Aiding in Orientation.
(1) Drawing. Frank Kerekes, Iowa State College.
(2) Surveying. Philip Kissam, Princeton University.
(3) Shops. W. R. Lindley, Purdue University.
General discussion.
(b) General Engineering Departments and Engineering Problems Courses. E. R. Wilcox, University of Washington.
(c) Modified Science Courses.
(1) Chemistry. Wm. D. Turnbull, Ohio State University.
(2) Mathematics. Wm. D. Tallman, Montana State College.
General discussion.

TECHNICAL INSTITUTES

WALTER B. RUSSELL, Franklin Union, *Chairman*

Wednesday

7:00 P.M. Industrial Economics. (General Topic.)
The Technical Institute's Responsibility for Educational Experimentation under Changing Industrial Conditions. Charles R. Mann, Washington, D. C.
Methods Found Successful in Selecting Vocationally-minded Candidates for Technical Institute Training. S. S. Edmands, Pratt Institute.
What Shall the Engineering College Do with Students who Turn Out Vocationally-minded Rather than Professionally-minded? By suitable sifting at time of entrance, is it possible to avoid this situation? Harold N. Cummings, Newark College of Engineering; William H. Timbie, Massachusetts Institute of Technology; H. H. Higbie, University of Michigan.
The Advantages and Disadvantages That have been Demonstrated by Experience of Conducting Technical Institute Training in the same Institution with Degree-granting Courses. Arthur C. Jewett, Carnegie Institute of Technology; Frederic H. Sexton, Nova Scotia Technical College.
What is Industry's Attitude Regarding the Employment of Degree vs. Non-degree Men for Supervisory Positions in Manufacturing and Industry? Carl S. Coler, Westinghouse Technical Night School; Cyril M. Jansky, University of Wisconsin.

Thursday

9:00 A.M. Robert I. Rees, American Tel. & Tel. Company, Chairman.
How Shall There be Organized for Technical Institute Students a Program of Training in In-

dustrial Economics that May Serve as a Foundation and Guide for Sound Thinking or Experimentation in the Field of the Economic, Social and Human Aspects of Industrial Engineering? Walter B. Russell, Franklin Union.

Scientific Measurements of the Influence of Different Human Factors on the Rate of Production. Thomas N. Whitehead, Harvard Graduate School of Business.

An Economist's View—Demonstrating the Need of Sound Economic Guidance for Industry.

Experimentation in the Field of Measurement of Various Capacities of Different Individuals. Harvey N. Davis, Stevens Institute of Technology.

USE OF MODELS IN LABORATORY TEACHING OF STRUCTURES AND HYDRAULICS

F. L. PLUMMER, Case School of Applied Science, *Chairman*

Tuesday

9:00 A.M. Opening Session: E. N. Burrows, Cornell University, Chairman.

New Goals for the S.P.E.E. Wm. E. Wickenden, President of the Society.

A Conference on Models—Why? Fred. L. Plummer, Case School of Applied Science.

The Laws of Similitude.

Discussion.

2:00 P.M. **Structural Section.** E. K. Timby, Princeton University, Chairman.

Fundamental Principles of the Deformeter Method of Model Analysis. Hale Sutherland, Lehigh University.

Photo-Elasticity—A Short Explanation of the Optical Principles Involved. T. H. Evans, Yale School of Engineering.

Various Types of Loaded Models and Some Problems to Which Their Use is Adapted. H. J. Gilkey, Iowa State College.

Hydraulic Section. K. C. Reynolds, Massachusetts Institute of Technology.

Equipment of the Hydraulic Experimenter.

a. Mathematical:

Dimensional Analysis as Related to Hydraulic Model Studies. R. W. Powell, Ohio State University.

b. Physical:

U. S. Waterways Experiment Station and Its Equipment. (Movies and slides.)

Iowa Institute of Hydraulic Research. (Movies and slides.) F. T. Mavis, University of Iowa.

University of Maine Laboratory. W. J. Sweetser.

Visit to Cornell Hydraulic Laboratory with class-room demonstrations by Professor E. W. Schoder.

Wednesday

9:00 A.M. **Structural Section.** George E. Large, Ohio State University, Chairman.

Illustrations of the Application of Loaded Models. J. C. Rathbun, College of the City of New York.

Place of Photo-Elasticity in Engineering Instruction. M. M. Frocht, Carnegie Institute of Technology.

Illustrating Structural Problems with the Deformeter Method of Model Analysis. J. T. Thompson, Johns Hopkins University.

Studies of Earthquake Stresses by Models. Lydik S. Jacobsen, Stanford University.

Experimental Analysis of Dams. J. L. Savage, U. S. Bureau of Reclamation.

Hydraulic Section. E. W. Schoder, Cornell University, Chairman.

Hydraulic Laboratory as an Aid to the Student.

How Water Flows in a Pipe Line. L. J. Hooper, Massachusetts Institute of Technology.

Coördinated Program of Hydraulic Instruction by Demonstration, Lecture and Experiment. E. W. Schoder, Cornell University.

Use of Models in Studying the Hydraulic Features of Dams. C. W. Hubbard, Worcester Polytechnic Institute.

2:00 P.M. **Structural Section.** F. W. Slantz, Lafayette College, Chairman.

Suspension Bridge Models as Used in Research. George E. Beggs, Princeton University.

Graduate Research Employing Photo-Elastic Methods. G. B. Karelitz, Columbia University.

Thesis on Torsional Problems—The Correlation of Structural Models and the Soap Film Analogy. Bruce Johnston, Lehigh University.

Use of the Deformeter in an Experimental Thesis —A Multiple Span Continuous Concrete Arch Bridge on Elastic Piers.

Hydraulic Section. C. L. Walker, Cornell University, Chairman.

Small-Scale Studies of Sanitary Engineering Problems.

Studies of Filter Sands. G. M. Fair, Harvard University.

Hydraulic Analysis of Water Distribution Systems by Means of an Electric Network Analyzer. T. R. Camp and H. L. Hazen, Massachusetts Institute of Technology.

Thursday

9:00 A.M. Fred L. Plummer, Case School of Applied Science, Chairman.

Present Trend in the Structural Engineering Field of Teaching. C. T. Morris, Ohio State University.

CAMPUS HEADQUARTERS AND REGISTRATION

The Campus Headquarters will be in Willard Straight Hall which is located on Central Avenue on the Cornell Campus. The headquarters will be open continuously from 7:00 A.M. to 2:00 A.M.

The Campus may be reached from the depots by street car (fare 10c) or by taxi (fare generally 50c). The Committee on Transportation will have cars to meet all trains and transport members of the S. P. E. E., their families and guests to the Campus Headquarters and the dormitories free of charge.

Registration Headquarters will be located in the Main Lobby of Willard Straight Hall. Members of the Registration Committee will be on duty from 7:00 A.M. to 9:00 P.M. daily throughout the convention.

The City of Ithaca and Cornell University operate on Eastern Standard Time throughout the year.

HOUSING

Living quarters during the convention may be obtained at:

Ithaca Hotel: 125 rooms, 75 with bath. European plan.

Single room without bath	$2.00
Double room without bath	3.00 and $4.00
Single room with bath	2.50 and 3.00
Double room with bath	5.00 and 6.00

Clinton House: 60 rooms. European plan.

Single room without bath	$2.00
Single room with bath	2.50 and $3.00

Double rooms at double the rate for single rooms.

These hotels are at the foot of the hill about a mile from the Campus Headquarters.

University Dormitories: The University has dormitory facilities sufficient to house all who desire quarters therein. All dormitories are located on the Campus. The rates charged are:

$2.00 per day per person for first two days.
$1.00 per day per person after first two days.

Camps: There are a few cabin camps approximately three miles from Ithaca. The rates in the past have been $1.00 per day. There are facilities for camping at:

Stewart Park in the City of Ithaca. This camp is approximately two miles from the Campus.
Enfield State Park about nine miles from the Campus.
Taughannock State Park on Cayuga Lake about ten miles from the Campus.

MEALS

Meals may be obtained in the cafeteria and dining rooms of Willard Straight Hall, the Convention Headquarters.

COMMUNICATIONS

Mail and telegrams should be addressed S. P. E. E. Headquarters, Willard Straight Hall, Cornell University, Ithaca, N. Y. To reach S. P. E. E. Headquarters by telephone call Ithaca 3361.

OFFICERS OF THE SOCIETY

President

W. E. WICKENDEN, Case School of Applied Science

Vice Presidents

F. V. LARKIN, Lehigh University
B. M. BRIGMAN, University of Louisville

Treasurer

W. O. WILEY, New York City

Secretary

F. L. BISHOP, University of Pittsburgh

LOCAL COMMITTEES

General Committee

W. L. Conwell, Chairman

J. R. Bangs, Jr., R. F. Chamberlain, J. E. Perry, W. M. Sawdon, E. M. Strong, R. Y. Thatcher, D. S. Kimball, H. Diederichs, P. M. Lincoln, P. H. Underwood.

Housing and Exhibits

R. F. Chamberlain, Chairman

L. A. Burckmyer, V. R. Gage, H. H. Schofield, F. G. Switzer, C. L. Walker, K. D. Wood, C. R. Kingston, W. D. Moeder, E. R. Paige, F. J. Spry.

Registration and Information

E. M. Strong, Chairman

E. V. Howell, C. O. Mackey, B. K. Northrop, M. G. Northrop, A. F. Boyles, S. F. Cleary, W. W. Cotner, W. E. Meserve, J. R. Moynihan, L. F. Welanetz.

Entertainment and Reception

J. E. Perry, Chairman

W. M. Sawdon, Vice-Chairman

C. D. Albert, W. N. Barnard, W. C. Ballard, E. N. Burrows, R. E. Clark, W. R. Cornell, C. Crandall, F. O. Ellenwood, S. G. George, T. McLean, H. C. Perkins, C. E. Townsend, L. J. Chawner, C. M. Pendleton, H. L. Goodman, A. N. Vanderlip.

Transportation

J. R. Bangs, Jr., Chairman

R. Y. Thatcher, Vice-Chairman

W. C. Andrae, S. L. Boothroyd, A. C. Davis, S. S. Garrett, W. H. Hook, D. S. Kimball, Jr., L. A. Lawrence, M. A. Lee, M. G. Malti, C. E. O'Rourke, M. A. Pond, F. S. Rogers, E. W. Schoder, A. E. Wells, G. R. Hanselman, R. C. Morris, C. I. Millard, R. L. Roy, J. P. Wood.

Ladies' Entertainment

Campus: Mrs. P. H. Underwood, *Chairman,* Mrs. C. D. Albert, Mrs. W. N. Barnard, Mrs. E. N. Burrows, Mrs. W. D. Moeder, Mrs. D. Ramadanoff, Mrs. C. L. Walker.

Special: Mrs. J. P. Wood, *Chairman,* Mrs. A. F. Boyles, Mrs. W. H. Hook, Mrs. R. C. Morris, Mrs. M. G. Northrop, Mrs. F. J. Spry, Mrs. C. L. Walker.

Tours: Mrs. F. O. Ellenwood, *Chairman,* Mrs. Carl Crandall, Mrs. V. R. Gage, Mrs. True McLean, Mrs. B. K. Northrop, Mrs. A. N. Vanderlip, Mrs. C. L. Walker.

A special committee to take care of children has been organized.

ENTERTAINMENT

At 4:00 P.M., Thursday, June 21, there will be a tour of the nearby State Parks.

On Thursday evening, June 21, there will be an informal social get-together in the Memorial Hall of Willard Straight Hall.

The annual dinner will be held on Friday, June 22, at seven o'clock in the Memorial Hall of Willard Straight Hall.

A reception and tea will be given by the University on Wednesday, June 20, at 4:30 P.M.

LADIES' PROGRAM

A separate program will be available at the time of the meeting. The Lounge for Women in Willard Straight Hall will be the rendezvous for visiting ladies.

CONFERENCE COMMITTEES

Unit Process in Chemical Engineering. F. C. Vilbrandt, Iowa State College, *Chairman;* Joseph C. Elgin, Princeton University, Secretary; H. L. Goodman, Cornell University; G. H. Montillon, University of Minnesota.

Civil Engineering. L. E. Conrad, Kansas State College, *Chairman;* Frank Kerekes, Iowa State College; I. C. Crawford, University of Idaho; F. L. Plummer, Case School; B. R. Van Leer, University of Florida; D. B. Steinman, New York City.

Coöperative Plan of Education. J. E. McDaniel, Georgia School of Technology, *Chairman;* W. H. Timbie, Massachusetts Institute of Technology; R. C. Disque, Drexel Institute; C. W. Park, University of Cincinnati; W. L. Conwell, Cornell University.

Deans and Administrative Officers.

Drawing and Descriptive Geometry. H. M. McCully, Carnegie Institute of Technology, *Chairman;* Thos. E. French, Ohio State University; Frank M. Warner, University of Washington; W. E. Farnham, Tufts College; C. V. Mann, Missouri School of Mines; Carl L. Svensen, Texas Technological College; E. F. Tozer, Northeastern University; Justus Rising, Purdue University; C. E. Townsend, S. F. Cleary and W. L. Conwell, Cornell University.

Electrical Engineering. F. E. Johnson, Iowa State College, *Chairman;* A. C. Stevens, Schenectady, N. Y.; H. L. Bibber, Ohio State University; E. A. Bureau, University of Kentucky; M. S. Coover, University of Colorado; P. S. Biegler, University of Southern California.

Electronics and Electrical Communication. W. L. Everitt, Ohio State University, *Chairman;* John R. Martin, Case School of Applied Science, Secretary; H. A. Brown, University of Illinois; O. W. Eshbach, American Tel. & Tel. Co.; W. C. Ballard, Cornell University.

Engineering Economy.

Engineering Research. C. F. Harding, Purdue University, *Chairman;* S. M. Woodward, University of Iowa; W. O. Hotchkiss, Michigan College of Mining and Technology; C. H. Berry, Harvard University; T. H. Morgan, Worcester Polytechnic Institute; C. B. Veal, New York City.

English. Sada A. Harbarger, Ohio State University, *Chairman;* H. L. Creek, Purdue University; W. O. Birk, University of Colorado; A. C. Howell, University of North Carolina; Amy V. Hall, University of Washington; J. R. Nelson, University of Michigan; W. F. Scammon, University of Maine; J. L. Vaughan, University of Virginia; C. L. DeLaBarre, Virginia Polytechnic Institute; R. P. Sibley, Cornell University; W. R. Dumble, Ohio State University, Secretary.

Fluid Mechanics. H. L. Mason, Columbia University, *Chairman;* P. A. Hemke, Case School of Applied Science, Secretary; F. G. Switzer, Cornell University; R. A. Dodge, University of Michigan; W. E. Howland, Purdue University; K. G. Merriam, Worcester Polytechnic Institute.

The program was arranged in coöperation with the Executive Committee of the Mechanics Division. A. E. Norton, Harvard University, *Chairman;* Z. R. Bliss, Brown University; H. D. Churchill, Case School of Applied Science; W. R. Cornell, Cornell University; S. B. Folk, Ohio State University; N. C. Riggs, Carnegie Institute of Technology; F. B. Seeley, University of Illinois.

Heat Transfer. F. C. Stewart, Pennsylvania State College,

Chairman; E. R. Queer, Pennsylvania State College, Secretary; F. C. Hottel, Massachusetts Institute of Technology; W. J. King, General Electric Company; A. M. White, A. O. Hougan, University of Wisconsin.

Industrial Engineering. P. T. Norton, Virginia Polytechnic Institute, *Chairman;* C. E. Bullinger, Pennsylvania State College; E. L. Grant, Stanford University; E. D. Hay, University of Kansas; E. D. Smith, Yale University; R. M. Barnes, University of Iowa.

Junior Colleges. R. A. White, Grand Rapids Junior College, *Chairman;* F. O. Rose, Modesto Junior College; A. C. Gough, University of Idaho; A. G. Gehrig, Pasadena Junior College; F. C. Bolton, Texas A. & M. College; H. H. Jordan, University of Illinois.

Laboratory Procedure in Teaching Machine Production. Ralph M. Barnes, University of Iowa, *Chairman;* R. L. Sweigert, Georgia School of Technology, Secretary; M. A. Lee, Cornell University.

Laboratory Uses of Models in Structures and Hydraulics. Fred L. Plummer, Case School of Applied Science, *Chairman;* E. K. Timby, Princeton University; F. W. Slantz, Lafayette College; K. C. Reynolds, Massachusetts Institute of Technology; H. D. Vogel, Corps of Engineers, Vicksburg; G. E. Large, Ohio State University; R. W. Powell, Ohio State University; E. N. Burrows, E. W. Schoder, H. H. Schofield and C. L. Walker, Cornell University; J. C. Rathbun, College of the City of New York; E. J. Squire, Brooklyn Polytechnic Institute; Gordon Fair, Harvard University; C. R. Young, University of Toronto; M. F. Sayre, Union College; T. F. Hubbard, Johns Hopkins University; H. A. Thomas, Carnegie Institute of Technology; R. J. Roark, University of Wisconsin; T. J. Dolan, University of Illinois; L. C. Hollister, Purdue University; B. R. VanLeer, University of Florida; R. L. Daugherty, California Institute of Technology; J. R. Griffith, Oregon State College; C. E. Bardsley, University of Missouri; L. E. Grinter, Texas A. & M. College; S. M. Woodward, University of Iowa.

Machine Design. Frank L. Eidmann, Columbia University, *Chairman;* J. M. Foster, North Carolina State College; W. M. Clapp, ...; O. A. Leutwiler, University of Illinois; Edgar MacNaughton, Tufts College, Secretary; E. F. Garner, Cornell University.

Mathematics. R. S. Burington, Case School of Applied Science, *Chairman;* J. H. Weaver, Ohio State University, Secretary; V. S. Lawrence, Cornell University.

Mechanical Engineering. B. G. Elliott, University of Wisconsin, *Chairman;* H. B. Dirks, Michigan State College; J. J. Wilmore, Alabama Polytechnic Institute; F. W. Marquis, Ohio State University; A. B. Domonoske, Stanford University; F. L. Eidmann, Columbia University.

Pre-College Guidance and Freshman Orientation. F. C. Dana, Iowa State College, *Chairman;* E. R. Wilcox, University of Washington; C. V. Mann, Missouri School of Mines; D. S. Anderson, Tulane University; A. V. Millar, University of Wisconsin; D. S. Kimball, Jr., Cornell University.

Technical Institutes. W. B. Russell, Franklin Union, *Chairman;* H. N. Cummings, Newark College of Engineering; F. E. Dobbs, Wentworth Institute; John T. Faig, Ohio Mechanics Institute; H. H. Higbie, University of Michigan; C. M. Jansky, University of Wisconsin; J. A. Randall, Rochester Mechanics Institute; W. H. Timbie, Massachusetts Institute of Technology.

THE S. P. E. E. MEETING AT CORNELL UNIVERSITY, ITHACA AND THE FINGER LAKES REGION

Cornell University is situated at the southern end of Lake Cayuga in the heart of the Finger Lakes region, so called, in the center of New York State. These long narrow and deep lakes are great furrows plowed in the earth by glacial tongues and the entire region is of great interest geologically. Seneca Lake, the largest of these bodies of water, is roughly 40 miles long, 5 miles at the widest point and 600 feet deep, its floor being 200 feet below sea level. Cayuga is about the same length, but not quite so wide and only 450 feet deep. The entire region is rolling in character, very fertile, and picturesque. The many streams that flow into these lakes have cut deep gorges in the rocky hill sides and some of these as Watkins Glen at the southern end of Lake Seneca and Enfield and Taughannock near Ithaca are nationally famous. The Cornell Campus lies between two of these deep gorges and there are a number of others within easy access to the University. Auto trips will be arranged to several of these, notably Enfield Glen which is nearby.

The entire region is accessible over very good roads for those who come in their own cars. Visitors from the west by the way of Chicago will find a through car from that city over the Michigan Central R. R. Others coming east over the New York Central Lines from Pittsburgh, St. Louis, etc., must change cars at Buffalo for the Lehigh Valley R. R. From New York the Lehigh Valley R. R. operates sleepers that are detached at Ithaca and there is through car service over the Reading R. R. from Philadelphia. From New England the best approach is over the New York Central Lines to Syracuse and by bus from that point to Ithaca.

The Meeting

Preparations for the meeting are going on apace. President Wickenden's idea of conferences preceding somewhat the main meeting of the Society appears to awaken a good response. Up to date the following list of conferences have been arranged for, and more are expected to follow.

Electronics and Electrical Communication, Professor W. L. Everitt, Ohio State University, Chairman.

Use of Models in Laboratory Teaching of Structures, Hydraulics

and Sanitary Engineering, Professor F. L. Plummer, Case School of Applied Science, Chairman.

Mechanics of Fluids, Professor H. L. Mason, Columbia University, Chairman.

Unit Processes in Chemical Engineering, Professor F. C. Vilbrandt, Iowa State College, Chairman.

Heat Transfer, Professor F. C. Stewart, Pennsylvania State College, Chairman.

Pre-College Guidance and the Orientation of Freshmen, Professor F. C. Dana, Iowa State College, Chairman.

Division of Drawing and Descriptive Geometry, Professor H. M. McCully, Carnegie Institute of Technology, Chairman.

English, Professor S. A. Harbarger, Ohio State University, Chairman.

Coöperative Division, Professor J. E. McDonald, Georgia School of Technology, Chairman.

Junior Colleges, Professor R. A. White, Grand Rapids Junior College, Chairman.

Laboratory Procedure in Teaching Machine Production, Professor Ralph M. Barnes, The State University of Iowa, Chairman.

Mathematics, Professor R. S. Burington, Case School of Applied Science, Chairman.

Technical Institutes, Professor W. B. Russell, Franklin Union, Boston, Chairman.

Program for the Women

The women of the Engineering Women's Club of Cornell University place themselves at the disposal of visiting women and have arranged the following special program of entertainment for women guests. The South Lounge of Willard Straight Hall will be headquarters for the women's activities. Here members of the local committees will be in attendance and will be glad to give any information or assistance. The program of entertainment follows.

Tuesday, June 19

3:30 P.M. Informal tea. Women's Lounge, Willard Straight Hall.

7:00 P.M. Dinner for the wives of the Members of the Council. Tea Room, Willard Straight.

Wednesday, June 20

10:00 A.M. Local auto trip or hikes,* to be signed up for when registering.

4:30 P.M. General reception and tea given by the University, Memorial Hall, Willard Straight.

* Auto trip about the Campus, and tour of buildings.

8:00 P.M. Bridge Party. Drawing Room Unit 1, Balch Hall. Husbands of women guests also will be welcome.

Thursday, June 21

10:00 A.M. Local auto trips or hikes,† to be signed up for the day previous.

1:00 P.M. Luncheon. Memorial Hall, Willard Straight, 60c a plate.

(4:00 P.M. Auto trip to State Parks. General).

(8:00 P.M. Informal get-together and Musicale. General).

Friday, June 22

10:00 A.M. Inspection of new Home Economics Building, with student guides.

3:00 P.M. Garden Party. Prudence Risley Hall.
Interpretative Dancing. Please secure admission cards when registering or at the Women's Headquarters before Wednesday evening.

Saturday is left open for any arrangements that may be desired.

Those desiring to use their own cars for any of the auto trips are asked to leave their names at Women's Headquarters at the time they register for these rides. Local women will be glad to act as guides for such cars.

Auto trips will start from Willard Straight Hall.

Other Entertainment

Golf will be available at the Country Club. The registration badge will admit to the Course which is a good 18 hole course. A special reduced greens fee of $1 per day will be charged. Tennis will also be available at the University Courts on the Campus and no charge will be made for this service.

All guests should report on their arrival at Willard Straight Hall for registration and assignment to rooms. While there is ample space in the residential halls, it will facilitate the arrangements if the return postal cards are returned as promptly as possible.

† Auto trip about the city, lake front, through Cascadilla Gorge, and Fall Creek Gorge.

A COURSE IN ADVANCED SHOP PRACTICE AS TAUGHT AT THE UNIVERSITY OF MICHIGAN IN 1933–1934 *

By A. P. GWIAZDOWSKI

Assistant Professor of Shop Practice [1]

This course is listed in the University catalogue as Shop 4A.

Projects

The students had a choice of bringing their own projects to work on, or worked on those assigned to them by the instructor in charge. If they wished to work on their own devices, a tracing of the layout and detail drawings were submitted to the instructor before work was started. A set of blueprints was made for the departmental record. The department furnished assembled drawings for its own projects, but the students made sketches of the details and worked from them.

Supervision

The shop instructors were not expected to volunteer any help unless asked for it by the students. This method places the student upon his own initiative, and allows him to use the knowledge he gained when he took Shop 4. He selects for himself the tool materials, speeds, feeds, methods of clamping his work, etc. In other words, he is given freedom of the shop. The instructor, however, watches the students, and, if any one of them is doing something radically wrong, he gets the proper instruction from the instructor in charge.

Classroom Work

One hour per week covered the subject of selecting materials for machine parts and the fabrication and machining processes. The selection of materials gives the student a chance to review his metallurgy. A bench drill press was used as demonstration material, the parts of which were used as examples. This machine (see Fig. 1) was designed as a school project in 1929, and all generally-used ferrous and non-ferrous metals were incorporated in it. The classroom discussions bring out, therefore, the advantages

* To be presented at the 42nd Annual Meeting, S. P. E. E., Cornell University, June 19–23, 1934.

[1] After September 15th, Associate Professor of Machine Production in charge of shop laboratories, Case School of Applied Science.

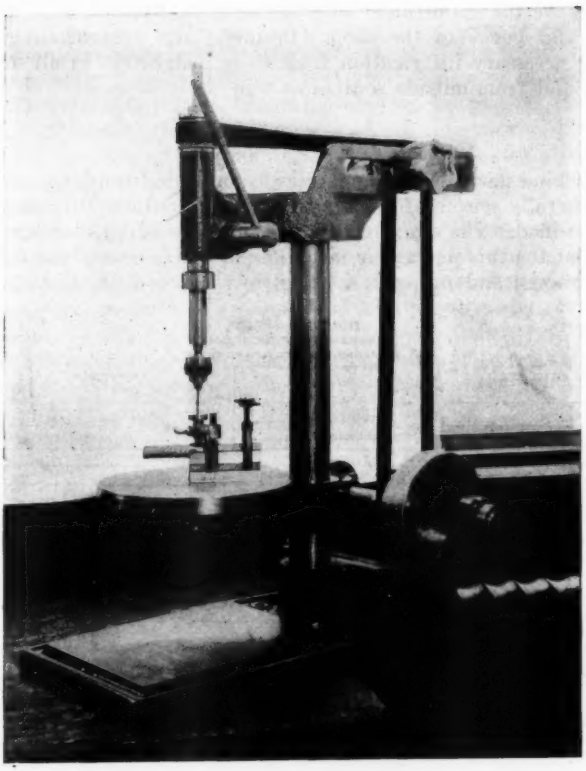


FIG. 1. Bench type drill press.

and disadvantages of different materials in their application to the specific cases.

The selection of iron and steel castings, forgings, and stampings helps to review the fabrication processes, and gives an opportunity to discuss mass production methods as used at the present time.

Machining processes cover a very extensive field. Comparisons of the economics of die casting versus stamping process, screw machines versus forging and centerless grinding, milling and shaping versus surface broaching—give a complete inside story of the production methods used by the job shop, semi-production, and mass-production organizations.

Since this drill press is practically tooled up completely, stu-

dents have the opportunity of studying jigs, fixtures, dies, special tools, and gages in the shop. Besides, they are encouraged to gather necessary information from their instructors in all departments and from outside sources as well.

Reports

Machine parts, such as spindles, complicated brackets, or gears are generally selected for a report. The desired quantity and time are specified. The student gives reasons why he selected a certain material for this particular machine part. He selects the fabrication process, and prepares a complete routing sheet, Fig. 2. The

ROUTING SHEET
UNIVERSITY OF MICHIGAN
DEPARTMENT OF ENGINEERING SHOP

INSTRUCTOR: B

GRADE — REPORT: ____ CRITICISM: ____ AVERAGE: ____

STUDENT — SECTION 2 No. 15 — Name J. H. HANCOCK — Date ____

Name of Job	Job No.	Name of Machine Part	Material	Part No.
DRILL PRESS	264	TABLE ARM	C. I.	5

No.	OPERATION Name	MACHINE TOOL Manufacturer and Type of Machine Tool	No.	Cutting Tool Material, Size, Type	Speed of Work or Tool	Feed	Depth of Cut	Chuck, Steady Rest, Jig, Fixture, Vise, Clamp, etc.	Measuring Instruments, Gages, Layout Tools, etc.	Time in Hours
1	MILL BOSSES	MILWAUKEE PLAIN MILLER	57	1-6"×1¼-14 F.S.G. SLABS	44 FT. PER MIN	3.9 IN PER MIN	3/32 IN.	264-F,S	4 INCH OUTS CALIPER	1¼
	SEE FIG. 8-D									
2	DRILL 2⅛ IN. HOLE	PROD DRILL PR	82	2⅛ IN H. S.S. CORE DRILL	48 FT PER MIN	0.015 IN. PER REV.	5/32 IN.	264-J,S	——	¾
	SEE FIG. 8-E									

NOTE: USE OTHER SIDE, IF NECESSARY HAND IN ROUTING SHEET TO TOOL-CRIB CLERK *BEFORE STARTING NEW JOB*

Form 3041 9-33 3M

FIG. 2. Routing sheet.

time for simple operations he assumes, such as burring, loading, and unloading, and calculates the time for the important operations, such as turning, milling, drilling, etc.

If special work-holding devices, gages, or tools are needed, the student is expected to furnish free-hand sketches of his own conceptions. Finally, he prepares the most economical machine-tool layout for this particular machine part.

Textbook

No textbook was available and notes were used.

The Results

1. Choice of a project by the student creates interest in his work, especially if he is building the device of his own design.

2. While working from his own drawing, he realizes the importance of having the correct "engineering language." Standardization, necessity of tolerances and allowances, shop terminology, and proper design of machine parts are being made naturally clear to him.

3. By moving his part, especially if it is heavy, 400 to 500 feet from one machine tool to another in the process of manufacturing, he grasps the importance of progressive arrangement of machines as versus group method, or vice versa. The conveying system comes to his mind.

4. While operating some antiquated machine tool or poorly designed work-holding fixture, he immediately realizes the importance of the application of motion and time study in designing of machines and tools.

5. While selecting fabrication and machining processes, he is forced to look up articles in such magazines as *Iron Age, Machinery,* and *American Machinist.* He learns for the first time, generally, about the existence of the "Machinery Handbook" and "American Machinist Handbook."

6. His report is the coördination of many subjects he studied on the campus, their application and usefulness to the solution of

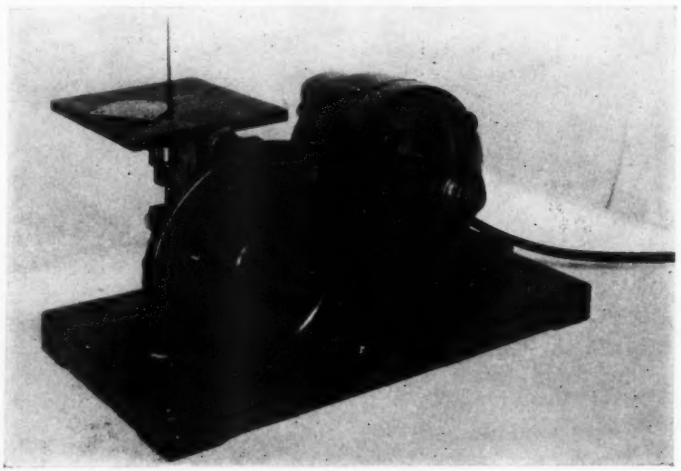


Fig. 3. The portable filing machine.

everyday engineering problems. It reflects quite strongly the student's general intelligence and ability to cope with engineering problems without outside guidance.

University Projects Designed and Built:

1 portable filing machine (Fig. 3).
6 stamping dies (piercing, compound, piercing and shaving, blanking, forming, and embossing, Fig. 4).

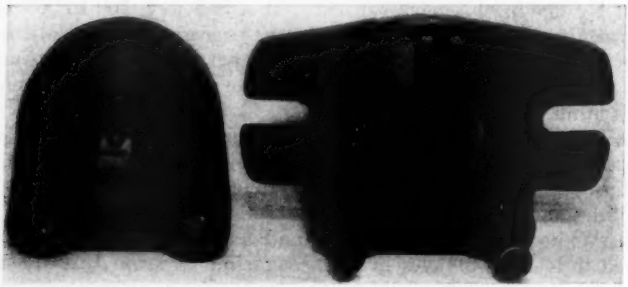


FIG. 4. The die for piercing 17/64-inch hole and shaving semicircular end *A*, Fig. 4b.

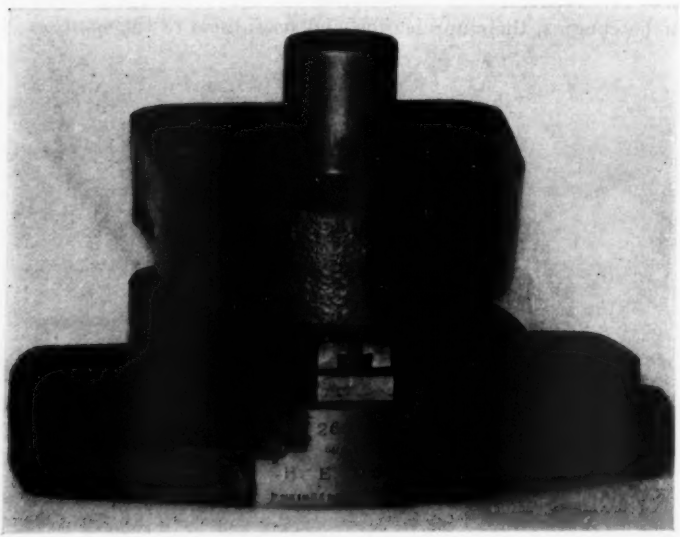


FIG. 4A. The die, shown in Fig. 4, in closed position. It was designed and built by H. E. Moore under the supervision of Mr. W. F. Bone.

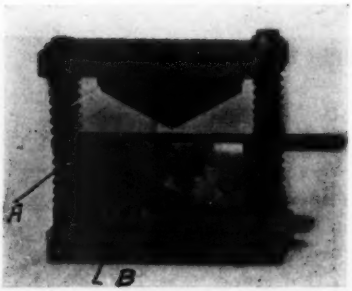


FIG. 4B. Hand-operated bending die built by V. Matulaitis.

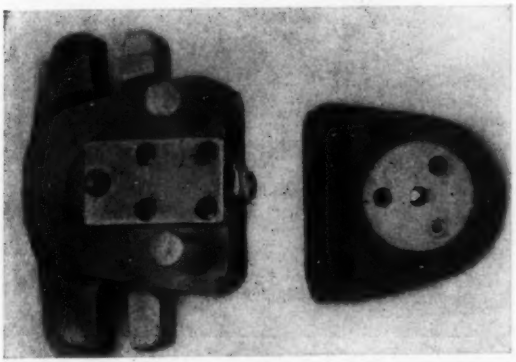


FIG. 4C. The die for piercing No. 7 (.201-inch) hole *B*, Fig. 4b. This die was designed and built by H. F. Loetz.

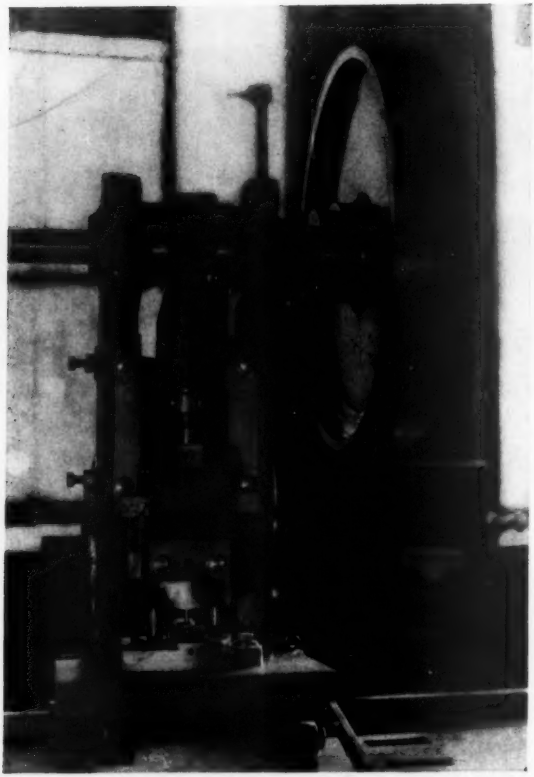


FIG. 5. Two-ton press built for piercing operation with the die shown in Fig. 4c.

1 two-ton power press (Fig. 5).
1 universal miller, model for teaching machine tool design (Fig. 6).
1 redesigned universal miller (Fig. 7).
45 jigs, fixtures, and special tools and gages (Fig. 8).

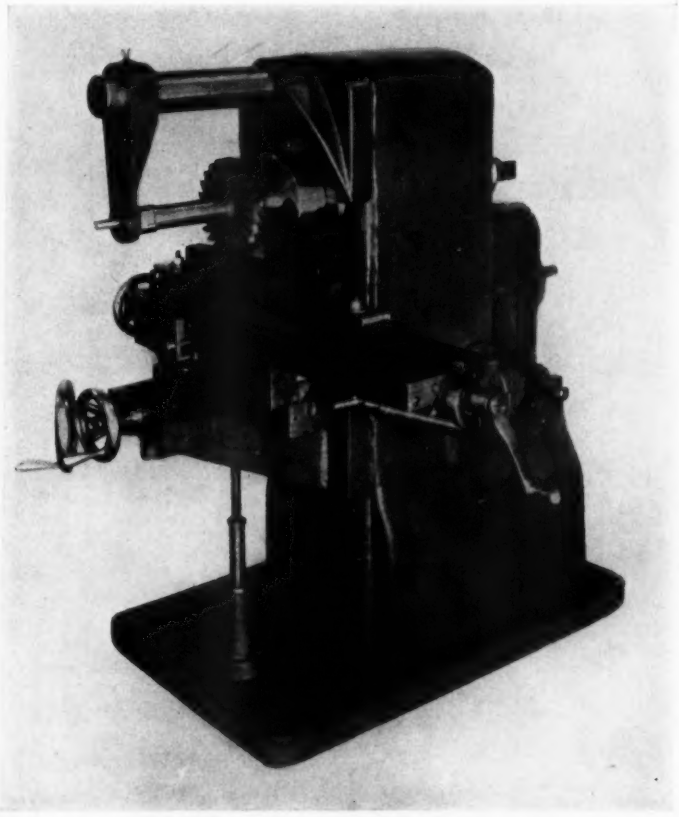


FIG. 6. The universal miller, weight about 700 lbs., designed and built to show *the features of a poor design*. This model was used in teaching machine tool design, listed as M. E. 21a.

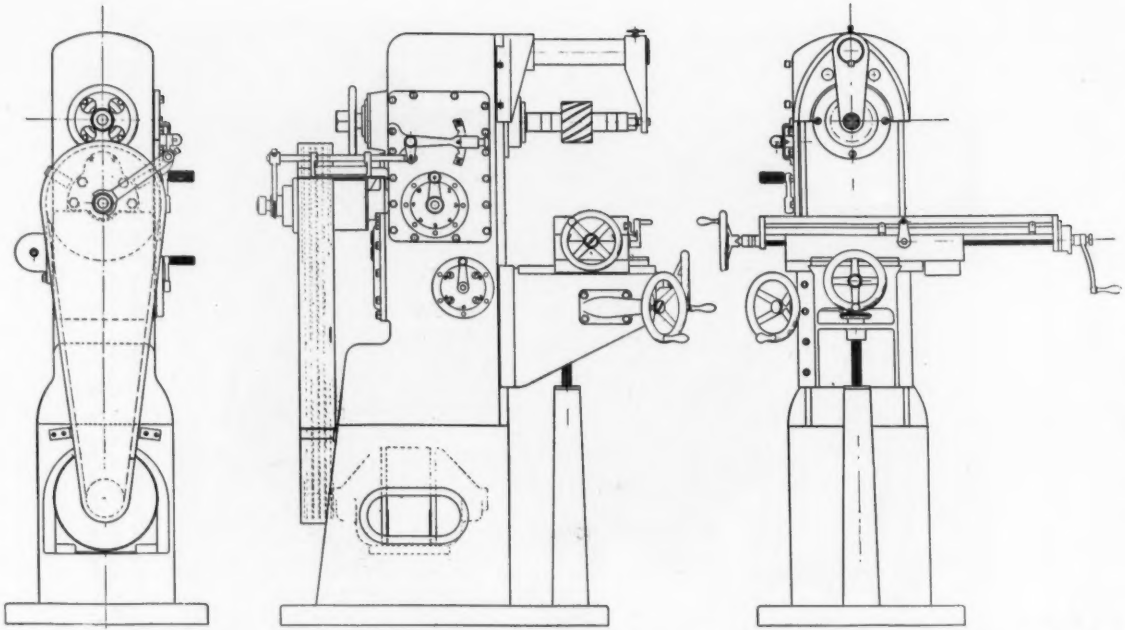


FIG. 7. The redesigned universal miller showing ultra-modern features. All controls are on one side, and can be reached by the operator from the front of the machine. Eight speeds and seven feeds are available. Speed and feed gears are shifted by cams and links. Forced lubrication is used. All important bearings are of roller and ball types. This machine is an ideal school project.

shifted by cams and links. Forced lubrication is used. All important bearings are of roller and ball types. This machine is an ideal school project.

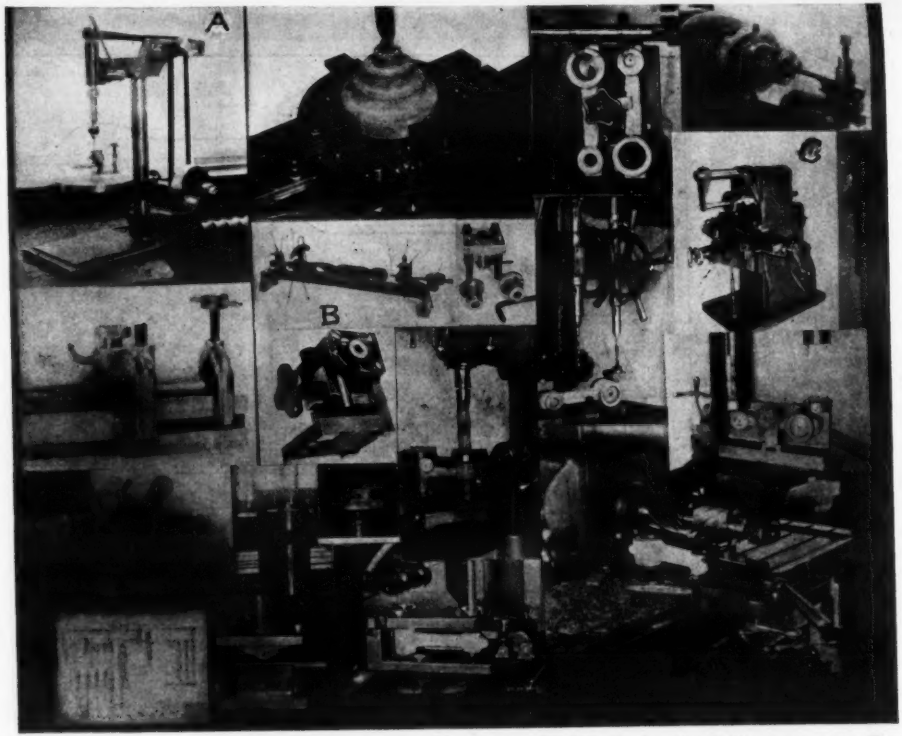


FIG. 8. Jigs, fixtures and gages designed and built by the students for the drill press parts, Figs. 1 and 8a.

Students' Projects:

1. Beam compass.
2. Power transmission for 80-horsepower marine engine (Fig. 9).
3. Gyroscopic pendulum for the Department of Engineering Mechanics, designed and built by F. H. Highley.
4. Beam deflection demonstration apparatus for the Department of Engineering Mechanics (Fig. 10).
5. Four-cylinder compressed air radial engine.
6. Planimeter.
7. Universal spring dynamometer with sixteen cantilevers for the Department of Engineering Mechanics.

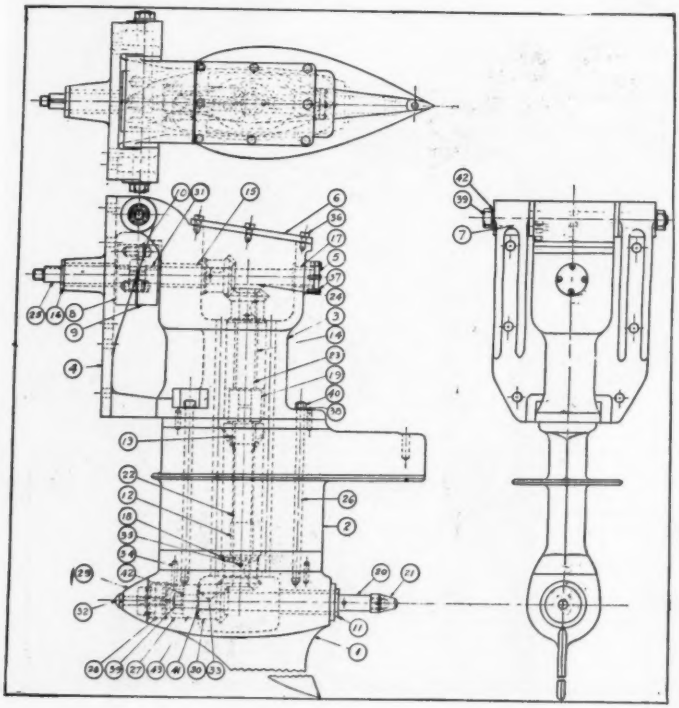


FIG. 9. Power transmission for 80 HP. marine engine designed and built by R. Preston.

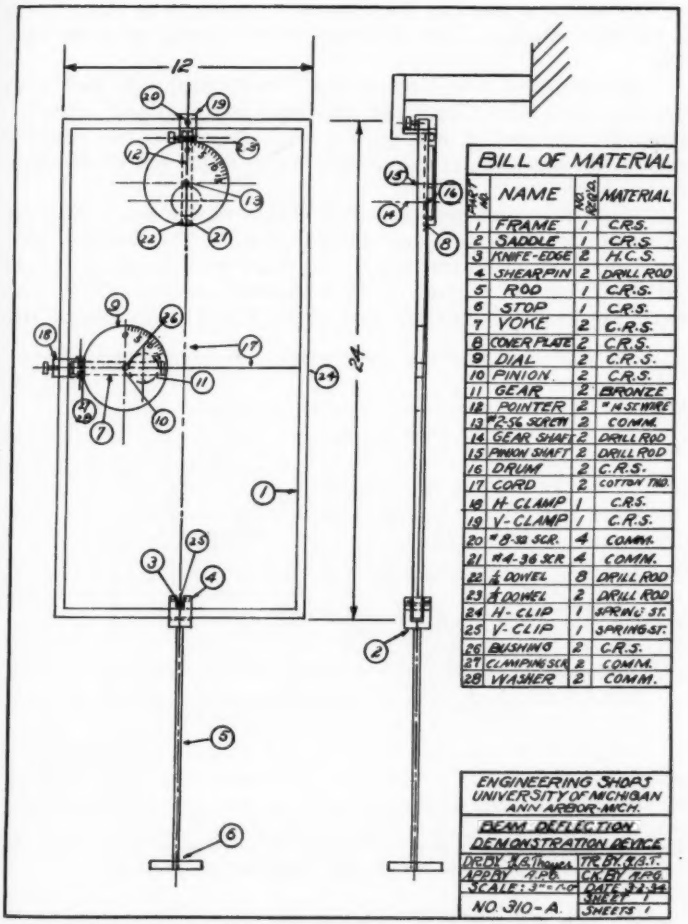

12
24
BILL OF MATERIAL
PART NO. | NAME | NO. REQD. | MATERIAL
1 | FRAME | 1 | C.R.S.
2 | SADDLE | 1 | C.R.S.
3 | KNIFE-EDGE | 2 | H.C.S.
4 | SHEARPIN | 2 | DRILL ROD
5 | ROD | 1 | C.R.S.
6 | STOP | 1 | C.R.S.
7 | YOKE | 2 | C.R.S.
8 | COVER PLATE | 2 | C.R.S.
9 | DIAL | 2 | C.R.S.
10 | PINION | 2 | C.R.S.
11 | GEAR | 2 | BRONZE
12 | POINTER | 2 | #14 SCHDRE
13 | #2-56 SCREW | 2 | COMM.
14 | GEAR SHAFT | 2 | DRILL ROD
15 | PINION SHAFT | 2 | DRILL ROD
16 | DRUM | 2 | C.R.S.
17 | CORD | 2 | COTTON TWD.
18 | H-CLAMP | 1 | C.R.S.
19 | V-CLAMP | 1 | C.R.S.
20 | #8-32 SCR. | 4 | COMM.
21 | #4-36 SCR | 4 | COMM.
22 | 1/4 DOWEL | 8 | DRILL ROD
23 | 1/4 DOWEL | 2 | DRILL ROD
24 | H-CLIP | 1 | SPRING ST.
25 | V-CLIP | 1 | SPRING ST.
26 | BUSHING | 2 | C.R.S.
27 | CLAMPING SCR. | 2 | COMM.
28 | WASHER | 2 | COMM.
ENGINEERING SHOPS
UNIVERSITY OF MICHIGAN
ANN ARBOR-MICH.
BEAM DEFLECTION
DEMONSTRATION DEVICE
DRDY G.B.Thayer
TR BY G.B.T.
APPRV A.P.S.
CK BY A.P.S.
SCALE: 3"=1.0"
DATE 12-32
SHEET 1
NO 310-A.
SHEETS 1

FIG. 10. Beam deflection demonstration device designed and built by G. B. Thayer.

Tool Engineering as Taught at the University of Michigan in 1933–1934

This course is listed in the University catalogue as Shop 7, Jig and Fixture Design. The class met twice a week, one hour each time.

"Economics of Tool Engineering" by Gwiazdowski and Lord (McGraw-Hill Book Company) was used as a textbook. The assignment consisted of one chapter each time, and the students brought the answers to the questions found at the end of the chapter.

After a few meetings, each student was assigned to design one jig, one fixture, one gage, and one special tool. The drawings were free-hand sketches on tracing paper. They were blueprinted, and each man received a print of his classmates' designs. They were given one week to study the first print, Fig. 11, the general dis-

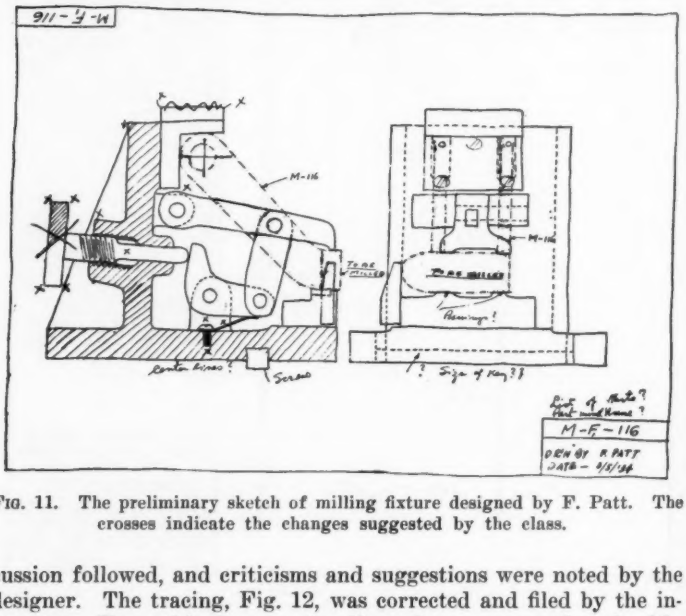


Fig. 11. The preliminary sketch of milling fixture designed by F. Patt. The crosses indicate the changes suggested by the class.

cussion followed, and criticisms and suggestions were noted by the designer. The tracing, Fig. 12, was corrected and filed by the instructor. From this time on, the discussions were continued without interruption.

The students also were required to prepare papers dealing with tool engineering and read them before the class. Suggestions and criticisms followed each paper.

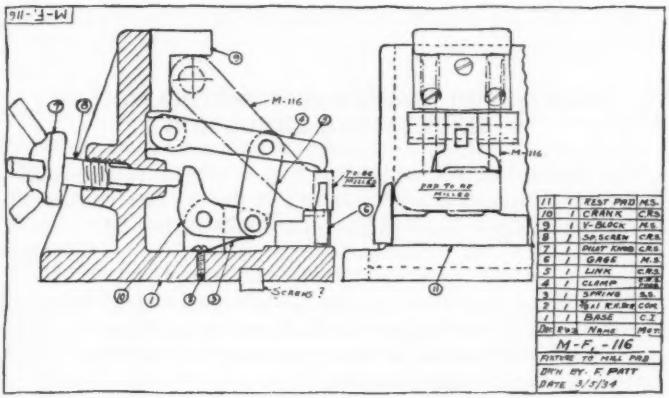


FIG. 12. The corrected sketch shown in Fig. 11.

Outstanding designs in the past years were described and published under the students' names in shop magazines. The same applies to the papers.

Mr. D. Gerdan's "Tool Engineering in Modern Large-Scale Forging," published in *"Machine Shop Engineering,"* Volume I (By Machine Shop Engineering, 1503 Shadford Road, Ann Arbor, Michigan), was highly praised by forge shop executives and manufacturers of forging machines.

"The Importance of Tool Engineering in Modern Industry," by C. M. Miller (Associate Professor of Engineering, University of Wichita) was published in the *Journal of the American Society of Tool Engineers,* Detroit, Michigan.

The method of free discussions and criticisms changes the classroom atmosphere. The students prepare their engineering sketches and papers carefully and they learn rapidly to defend their ideas and even errors. The instructor has an unlimited opportunity during these discussions to cover the major part of production engineering.

PREFACE TO VOLUME II INVESTIGATION OF ENGINEERING EDUCATION

The Preface to Vol. II of the Report of the Investigation of Engineering Education is preprinted here for the information which it contains. This volume will be distributed in the fall.

EDITOR.

This volume carries to completion ten years of activities conducted by the Society under the auspices of its Board of Investigation and Coordination in an undertaking to "develop, broaden and enrich engineering education."

An Expanding Program. Initially projected as at least a five-year enterprise, it was at first financed for a period of three years. The program developed and expanded as the undertaking progressed. Supplemental funds were secured as needs were definitely defined.

The initial period of fact-gathering and analysis was followed by the Study of Technical Institutes, by sessions of Summer Schools for Engineering Teachers during seven years, by the Conference of Administrative Officers. The Director made a second visit to Europe in his comparative study of engineering education in this country and abroad. The "1930 Survey" was made. Throughout these undertakings the Society has enjoyed a healthy activity. Interest has been stimulated in educational problems in individual institutions; there has been gratifying development of Sectional meetings at which members from adjacent institutions have discussed their common problems; new Sections have been established, the annual conventions have been accompanied by spirited conferences in Divisions devoted to specific subjects of instruction—all of which is reflected in the reports and discussions which have appeared in the Journal of Engineering Education and elsewhere. The Engineering Societies have become increasingly active in education.

PERSPECTIVE SUMMARY

It is fitting, therefore, at the beginning of the concluding Volume, to present a brief summary of the activities which the Board has initiated and sponsored and to present a brief statement of the publications arising from them.

The Beginning. The inception of the undertaking and the organization of the Board are described in the Foreword and Report

of the Chairman at the beginning of Volume I. Additional Preliminary and progress reports are listed in the Bibliography in this Volume.

Cooperation with Engineering Colleges. From the very beginning of its work the Board planned "To maintain close contact with engineering schools, enabling them to participate in the investigations and reporting to them from time to time to the end that the developments may be continuous from the initial contact between the colleges and the agencies of the Board." Such participation has been a unique feature of the project. The method of self-investigation of engineering education by engineering educators themselves—a method that was challenged—is discussed by the Director in the section of his report entitled "The significance of the cooperative plan of investigation," page 1042.

Through the JOURNAL OF ENGINEERING EDUCATION, the monthly journal of the Society, data and reports have been promptly furnished to its members. Reprints of reports and papers in two score of pamphlets have been widely circulated. They are listed under the Publications of the Board on page .

The two volumes of the completed report bring together these records in permanent form, indexed for reference. Volume I presents the data of the Fact-gathering stage of the investigation together with the reports of Faculty Committees, the Staff, and the Board, based largely on these data. It includes also the comparative study of engineering education in the United States and in Europe. Volume II contains reports, bibliographies and indexes, which are outlined in the following paragraphs.

The Final Report of the Director, W. E. Wickenden, who retired from the Staff September 1, 1929, was completed in 1933. It has a perspective enriched by experience as president of an engineering college and the new viewpoint which comes with the shift from 1929 prosperity to 1933 depression.

The General Report on Summer Schools, by the Director, Professor Hammond, covers the twelve sessions (1927–1933) which complete the cycle of the principal branches of the engineering curriculum. Selected Papers from the Summer School sessions have appeared in the JOURNAL OF ENGINEERING EDUCATION and in a series of pamphlets the titles to which are appended to this report. The contents of the pamphlets is listed under Publications of the Board, Selected Papers of the Summer School.

A Conference of Administrative Officers of Engineering Colleges was held in 1933 under the auspices of the Board for consideration of problems and policies of administrative character. The general report of the Conference is followed by a detailed pro-

gram in which certain papers are indicated as appearing in the Society's monthly publication.

The 1930 Survey of the Engineering Colleges was made under President Rees (a member of the Board) with the cooperation of the United States Office of Education. Its object was to secure data concerning engineering colleges primarily for comparison with the data for 1925 which were presented in Reports of June, 1926 and appear in Volume I. The survey also includes general information regarding the progress made in individual institutions during the five-year period. It has a significance which was not anticipated as it presents the conditions in engineering colleges at the beginning of the economic depression.

The Publications of the Society and of the Board, which have appeared in several serials or independently, are listed for convenient reference.

A Bibliography of articles relative to the activities of the Board which appeared in current publications (1922–1933) indicates the general interest in the problems of engineering education and make this contemporary material available for reference. It contains reference to preliminary and progress reports of the Board and Staff which are not included in the two bound volumes of its report. The Bibliography is selective and does not attempt to include all related articles of the decade.

The Index aims to be more than a list of words and titles. It contains many bibliographies of Bulletins and Reports dealing with particular subjects. Under Curricula, for example, are listed the dozen or more sections dealing with this subject. Reference is given not only to the pages of the text, but also to the pages of the Table of Contents (beginning on page xv) which itemizes subtitles and paragraphs; also to the Tables and Diagrams (beginning on page xliii) which are listed by titles.

This concludes the report of the Investigation of Engineering colleges.

Technical Institutes

The Report of the Study of Technical Institutes (non-collegiate) appears as Part 2 of this Volume II, with independent paging and index.

This supplemental Report was conducted by the Staff of the Board with counsel of an Advisory Committee. It was issued as a pamphlet in 1931 and was given wide distribution both in its complete form and also in a summary report of forty pages.

The Engineering Societies

The Board has advocated increasingly active participation of the National Engineering Societies in educational matters. They aided in the Investigation by securing through their committees the opinions of professional engineers concerning educational policies and practices which form the basis of Bulletin Number 13. They, together with the Engineering Foundation, contributed financially to the support of the Investigation and of the Summer Schools.

Concurrently with the activities of the Board the American Society of Mechanical Engineers conducted a survey of the economic status of its members which attracted wide interest. This was an important factor leading to the organization of the Engineers' Council for Professional Development of which the Society for the Promotion of Engineering Education is one of the seven cooperating member-organizations.

This promises active alliance between the professional engineering societies and the engineering colleges. It is a happy realization of an ideal which is expressed in the concluding paragraph of the Report of the Chairman, page 14. "The Board believes that the type of activity it has initiated should be continued. While much may be accomplished by individuals and faculties, engineering societies and industrial leaders, to all of whom engineering education is of vital importance, it is believed that a formal representative general agency, possibly an Engineering Education Foundation, would be of outstanding value in developing continuously engineering education as a potent factor in the progress and stabilization of a civilization based on machinery and power and applied science."

Charles F. Scott,
Chairman.

TRAINING FOR CITIZENSHIP *

By ROY V. WRIGHT

Managing Editor, Railway Age, and Past-President, American Society of Mechanical Engineers

Many thoughtful leaders and students of government have sounded warnings that because of the steadily increasing complexities in our modern economic, social and political life we may face disaster in this wonderful democracy of ours, unless our citizens generally can be inspired to take a larger and more intelligent interest in citizenship. In spite of this, it is rather startling to find that a young man or a young woman can be educated in our public schools and be graduated from our state universities without being given much, if any, specific information or coaching on how to meet their civic responsibilities.

Most of the textbooks on civics, whether intended for foreigners preparing for citizenship, or for general use, are largely concerned with descriptions of governmental processes and activities, with little suggestion in most of them as to any responsibility a citizen may have, and even less about how to discharge that responsibility. I even found a book in the public library a short time ago which was entirely given over to the outlining of what a citizen could expect his government to do for him.

Should not every college graduate, and particularly from institutions supported by public funds, be required to take a course in government, and be definitely challenged and instructed as to the discharge of his civic duties? Moreover, because of his special training and abilities, should this not apply with special force to the graduates of engineering colleges?

Someone, I have forgotten who, made the statement at the last annual meeting of the American Society of Mechanical Engineers that "science, controlled by the engineer, has remade the world." We may not fully agree with this evaluation, and yet we must admit that the work of the engineer has lightened the toil and removed drudgery from workers in every walk of life—industry, commerce, agriculture and the home. Higher standards of living which have resulted from his achievements have, however, brought with them difficult and complicated problems in our economic, social and political life.

* Presented at the Spring Meeting, Middle Atlantic Section, S. P. E. E., Haverford College, May 5, 1934.

It is not my purpose to single out the engineer for criticism. Other groups associated with him have had a large part in making his ideas effective. At the same time his very training and methods of working fit him in a special way to find the solution of some of the complicated problems which have followed in the wake of his achievements. Moreover, government—local, county, state and national—is more and more engaging in engineering projects of great significance and magnitude. Who better than the engineer can be helpful in his capacity as a citizen in assisting to educate his fellow citizens to the importance of these projects and to see that they are rightly planned and promoted in the interests of the community or state as a whole?

This is a problem which has intrigued President Allan R. Cullimore of the Newark College of Engineering and myself for a considerable time, and when we finally contacted with each other something was bound to happen. My own interest was first awakened because of a keen interest in the activities of the American Engineering Council, which for many years has represented the engineers of this country in public affairs. This interest was enhanced by experiences with engineers in the last two Presidential campaigns, and by open forums which I held quite generally with members of Local Sections and Student Branches of the American Society of Mechanical Engineers during my presidency of that organization in 1931.

Out of this interest, and with the co-operation of Major Cullimore, has developed a discussion course on "The Engineer's Duty as a Citizen" for the upper classmen at the Newark College of Engineering. This college, as you know, is a co-operative engineering institution, the juniors and seniors alternating between the classroom and industry at monthly intervals.

The basic material in the course was given to the students in pamphlet form at the beginning of the college year last fall. They are expected to study it carefully and be prepared to discuss it in three two-hour periods.

The first part of the pamphlet consists roughly of a certain amount of background material, including notes on what the engineer has done for humanity; the economic, social and political complications and evils growing out of his work; the engineer's responsibility for these results; the importance of citizenship in a republic in this mass production era; and the engineer as a citizen. This background material is brief, and while no formal bibliography is included, it does refer to several books, reports, addresses, etc. Certain key questions are given at the end of each section to stimulate the student's interest and to help him prepare more intelligently for the discussion.

The last part of the pamphlet is divided into four sections and discusses how the engineer can discharge his civic responsibilities as an individual, as a group in the local community, as a group in national affairs, and with a view to international relations. So far as possible, specific suggestions are made, and this is particularly true as to the engineer's duty as an individual, or as to the functioning of a group of engineers in a local community.

As there are only three two-hour periods for each group each year, and since the first period is used for the discussion of the background material, only four hours are available for the more intimate consideration of civic duties. One of these two-hour periods is used for the discussion of the engineer's civic duties as an individual, and the remainder of the material is covered in the third, or final, two-hour period.

It should be explained, also, that this study is not an independent unit in itself, but is part of a course given by President Cullimore to all junior and senior students; it is included in what might appropriately be designated an engineering orientation course.

What has been the result? First, as to the reactions of the students. It is of course impossible to evaluate this with any degree of accuracy, except on the basis of the extent to which they have entered into the discussions. These have been lively and filled to the brim and have brought out many practical problems relating to matters which have come under the student's observation in connection with local political activities, or based on experiences of some member of his family or close circle of acquaintances. Constructive suggestions have been made by the students, but in the main there has been a flood of questions relating to practical political problems or engineering ethics in relation to politics. Only time, however, can demonstrate how much of practical value will come from such a course.

Approaching an entirely new project of this sort, and building up a practical course, even though of a very limited nature, imposes a large effort and responsibility, and I have turned to my friends, and to those I thought could be helpful, for advice and counsel. At least 900 copies of the pamphlet have been sent to engineering educators; to engineers of all classes and types; to engineers and others in public service, either as office holders or specially interested in political and governmental activities; to experts in the field of character building, such, for instance, as ministers, Y. M. C. A. secretaries, etc. Judges and lawmakers have not been overlooked. Included in my list of correspondents have been a number of women who have had special experience in the fields of civics, welfare work and politics. I have tried also to get in

touch with people associated with various movements primarily engaged in civic educational work.

Out of this has come a wealth of material that is surprising and extremely gratifying. Some of it can be utilized to excellent advantage in revising the material in the pamphlet for the students. It has also served to strengthen my confidence in the project. Naturally, not a few of my friends have been exceedingly frank in directing attention to what they believed to be shortcomings in the attempt to present a course of this kind in so limited a time, or by the discussion method. Such comments have been most helpful in putting me on my guard in the effort to avoid possible pitfalls.

A group of members of the American Society of Mechanical Engineers was so impressed with the experiment that the Council of that Society has appointed a committee to consider the advisability of preparing a manual on citizenship for its members. Several of my correspondents have told me that they are using some of the material in the pamphlet in their classes, or in meeting with groups of young people.

The keen interest displayed by many engineers, and particularly by those who have had experience in public life or in dealing in an intimate way with governmental problems, leads me to believe that there are large possibilities in a project of this sort. I realize, possibly as well as most of those here present, the great difficulty we have in giving engineering students all those important things they should have in a college course. I know that it is almost impossible to jimmy more material into these courses, and yet I do sincerely believe that this is one of the fundamentals that must be included, not only in engineering courses, but in all college courses.

In closing, may I again emphasize the vital necessity of intelligent and active citizenship. Hon. Elihu Root is no alarmist. In 1907, when Secretary of State, he gave a series of lectures on "The Citizen's Part in Government" at Yale University. Remember that this was before the mass production era had gotten well under way. In his first lecture he made this significant statement: "Nevertheless, we must not delude ourselves with the idea that the American experiment in government is ended or that our task is accomplished. Our political system has proved successful under simple conditions. It still remains to be seen how it will stand the strain of the vast complications of life upon which we are now entering."

I am an optimist about the future of this country—an optimist, if we can awaken our citizens to take a reasonable and intelligent interest in government—a government which in these days of extreme specialization and interdependence touches each one of us intimately at every turn and in all our manifold activities.

THE ECONOMIC SEQUENCE IN THE CIVIL ENGINEERING CURRICULUM *

By J. K. FINCH

Renwick Professor of Civil Engineering, Columbia University

Introduction

There appears to be no need to-day of defending the thesis that, in planning a satisfactory engineering curriculum, due attention must be given to economics. Engineers and engineering teachers for a number of years past have called attention to the fact that the world in which we live has been so transformed through engineering activity that it would no longer be recognizable to our grandparents, and that, accompanying these material engineering changes, new economic and social problems have arisen which require engineering methods and the engineering viewpoint for their solution.

On the other hand, while we have thus talked of what should be done, an examination of engineering curricula shows that in general little actually has been done to make these elements of a liberal, truly professional, engineering training, a vital part of American engineering education. The reasons for this are obvious.

We have been put to it to find room in the usual four year engineering program to give even adequate attention to the rapidly changing and expanding fundamental sciences and to the ever increasing and ever more complicated technique of engineering practice. We have had no experience in handling economic problems in the class room. Discussion has failed to define in any detail the scope or character of the instruction to be offered and the teaching value of such subjects is problematical. In short, the saturation point has been reached; nothing can be added without crowding out something else; without abandoning well organized instruction of demonstrated importance for new topics of largely unknown educational values.

It was primarily in response to the demand for the broader professional training, a training which would give some attention to the social and economic phases of engineering activity that longer courses of study, five or six years instead of the usual four, were established at a few engineering schools, notably the Thayer School

* Presented at the Spring Meeting, Middle Atlantic Section, S. P. E. E., Haverford College, May 5, 1934.

at Dartmouth and the School of Engineering at Columbia, a number of years ago. I cannot speak for Dartmouth, but I know that our twenty-odd years of experience with the longer course at Columbia has demonstrated that the problem is not simply one of finding time for new subjects.

We began by introducing a general course in Economics in what we call our "pre-engineering" years; that is, the two or three years in our "arts college" at Columbia, which our students pass through before entering our Engineering School. Later, this subject was combined with certain other "liberal" college subjects to form a course known as Contemporary Civilization. This is required of every student in Columbia College. It carries through two years and involves 16 semester hours. After a brief review of the rise of modern civilization, a detailed study is made of the social, economic and political changes which began with the Industrial Revolution. We thought the problem had been solved. After a few years, however, it became clear that the student, while "exposed" to economic cogitation in his arts college work, promptly forgot about it when he passed over to the two (for B.S.) or three (for professional degree) years in the engineering school. Here, as in the past, he was swamped with a highly concentrated and exacting program of strictly technical subjects. The economic and social consequences of engineering activity were seldom mentioned, and interest in this phase of engineering was soon lost. In short, it was discovered that the problem could not be solved simply by introducing a general course on economics. It was, in fact, primarily an engineering school problem.

It has thus been necessary to develop in the engineering program itself a sequence of economic subjects, to study the best method of presenting such subjects, to determine what teaching values they possess, and to discover how these values may best be capitalized. Finally, it has been necessary to find men interested in and capable of handling these subjects, for it is unfortunately true that many engineering teachers and many practicing engineers have allowed purely technical matters to occupy their entire time and attention.

We believe we are on the road to a solution of the problem of making this instruction an interesting and vital part of our engineering program and of taking advantage of its teaching values in making better engineers. It is probably true that the plan we have developed cannot be followed by all schools—differences in number of students to be handled and in previous training will require differences in program and method. Nevertheless, I believe that we will never get beyond the talk stage unless we study, in more or less detail, definite projects of this type.

Economics in Civil Engineering

Economic considerations are so basic and fundamental in all types of engineering work that it has always been difficult for the writer to understand how any engineering subject can be presented and discussed without some reference to economy of design, construction or operation. For example, any treatment of truss bridge design would appear to involve a consideration of economic proportions, economic ratio of depth to span, etc. Similarly, any discussion of bridge building in general must involve the economic comparison of the different available types.

This element in engineering design is very old, and is very important. It dates back to at least 600 years B.C. and its importance was pointed out a number of years ago by Wellington, who remarked in his characteristically blunt and forceful manner, that it was the keen competitive struggle to secure economical design, rather than considerations on the part of the engineer, of his responsibility for human life, which has been the chief impelling force to technical progress.

This treatment of the more elementary of these purely technical matters of engineering economy have, in general, been well developed, and they receive some attention in the various subjects of the engineering course. In the writer's opinion, it would be a mistake to attempt to take them out of their natural setting and put them in a special course.

Before we have gone very far, however, in the economic comparison of different types of structures, we run into more complicated problems involving the economic combination of several structures, or, perhaps, structures involving different maintenance and operating costs, or even offering partial instead of complete satisfaction of the service contemplated.

The solution of these problems requires a considerable background of information as to economic factors and analysis, and it is one of the purposes of the first subject of our economic sequence to give the student some knowledge of these fundamental factors and methods. Furthermore, while many public works problems involve the same or similar economic considerations to those involved in private undertakings, the economic premises in public works construction are, to say the least, less definite. Accordingly, the earlier economic studies are confined to the presentation of the relatively simpler problems of engineering enterprise under private ownership. Public works come later.

Engineering Enterprise Under Private Ownership

Our present plan calls for a division of this field into two subjects,

C.E. 101. Introduction to Civil Engineering (1st year).
C.E. 136. Transportation Economics (2nd year).

In a rough way, the first of these subjects is planned as an introduction to the practice of civil engineering and to the simpler problems of civil engineering economics. Transportation economics carries the principles of economic analysis into the more involved considerations of traffic surveys, financial set-up, and operating costs.

Introduction to Civil Engineering (2 Semester Hours with Outside Reading)

It is obviously desirable that a civil engineering student should have some knowledge of the background of his profession and of his professional duties and responsibilities. The introductory lectures in this subject are therefore planned to meet this need. None of the topics is gone into extensively, the idea being primarily to call the students' attention to these elements of civil engineering practice. Some of the material is presented by lectures but, in several cases, the subject can be assigned to a student for report—he prepares a paper which, after correction and criticism, he presents in class.

In Part II of this introductory course, we note the various stages of an engineering enterprise under private ownership and the engineer's duties and responsibilities to his client in these various stages. The general analysis of the problem is illustrated in chart form. A brief discussion of the items listed brings out the part which economic considerations play in the various stages of an enterprise. Certain features, however, demand more extended discussion.

While we recommend that all of our students, who can find time for it, take "Corporation Finance," a subject offered by our School of Business, it is not possible to require it in our program. A brief outline of the various possible forms of "financial structure"—individual ownership, the partnership and the corporation—and of the different methods of raising funds—notes, mortgages, stock, bonds—is also given in Part II.

Part III deals with the strictly economic phases of design. Here we attempt to give the student some idea of what factors are involved in answering General Carthy's three famous questions, Why do it this way? Why do it at all? Why do it now? The analysis begins with the simple problems of economic comparison in which there is no difference in operating costs or service rendered. The discussion continues to include at least the basic elements of those comparisons in which operating costs, or even service, differ. Some

of these latter problems involve technical knowledge which the student does not secure until later in his course, and the main elements only are noted.

Part IV deals very briefly with the preparation of technical papers and reports. Our experience with the teaching of English composition indicates that the general treatment of this subject which our students receive in arts college needs, to say the least, considerable bolstering up through later practice in the engineering school. It would appear that the composition of essays on the character and pernicious activities of Mrs. Macbeth was not an over effective preparation for the writing of technical papers and reports. Furthermore, the primary object of education is the development of the student rather than the imparting of information, and we believe the preparation and presentation in class of papers and reports is one of the most effective means both of agitating the students' grey matter and of improving his written and spoken English. We use this method wherever possible and many economic topics are not only particularly suitable for such purpose but also involve valuable problems of analysis and presentation.

Transportation Economics

In this second subject of our sequence, we have in mind (1) giving the student some general idea of the background of the American transportation problem, a knowledge of which, we believe, is essential to any truly liberal civil engineering training, (2) developing the methods of analysis essential in handling problems involving varying traffic and operating factors, and (3) introducing some of the broader problems of general policy which are involved in our existing transportation tangle. At present, three men handle the subject. One, the general background, another the highway problems, and a third the railroad problems.

Public Works

It is, of course, true that the phenomenal development of the United States in the past has been largely a matter of individual initiative—of private enterprise. The engineer has been attached as expert technical advisor and special agent to those captains of industry who have gone hunting for profit in a well-stocked preserve where there were no game laws. Under these lassez-faire conditions, the engineer cannot be criticized for having done excellent work for his client.

It is becoming more evident every day, however, that this era of unrestrained competition offers insuperable obstacles to the development of a safe and sane social and economic order. No matter

how we may detest the papa and mama type of government that interferes with our individual interest and activities, it is obvious that governmental regulation and control of private enterprise is bound to increase and that the construction and administration of public works is rapidly becoming of greater importance.

The civil engineer in particular is involved in these problems. He cannot escape them. In railroad and also in hydraulic power work he is in contact with government regulation. Even more important, however, he is responsible for public works undertakings of ever increasing scope. Before the current unpleasantness, public works constituted over one third of the business of the construction industry and to-day they constitute an even higher part of this product of civil engineering activity.

We have therefore introduced in our civil engineering program a brief course devoted to the study of public works. This subject is given almost entirely by the students themselves. In the introductory part, some attempt is made to outline the various stages of a public works undertaking and to note possible variations of procedure in each of these stages. Having this background, each student prepares, with the advice and assistance of the instructor, a paper on one or more phases of the topic under discussion. The subject is then presented in class. Students are encouraged to analyze procedure or methods and to summarize by chart or diagram. In short, an effort is made to find an effective method of presenting the topics assigned.

These topics deal not only with the operation of federal, state and municipal public works bureaus or departments, but also with the forms of organization, the problems and difficulties of special public works undertakings. There is, of course, no ideal act or law which will insure honest, effective and efficient public works administration. There are, however, advantages and disadvantages in every type or form of organization which has been used or proposed. Some knowledge of these differences should aid the future engineer in his effort to secure the adoption of sound laws and policies in public works undertakings.

Conclusion

While it may be possible to offer a general sequence of economic subjects for all engineering students, we believe that this outline shows that the topics of interest to the civil engineer are of such special character and scope that they can be best handled by the civil engineering department.

We further believe that a sequence of this kind offers the opportunity of

1. Giving adequate attention to those economic considerations which determine the scope and, in a large measure, the character and very details of engineering practice.

2. Continuing and developing throughout the civil engineering course, the interest of the student in the economic and social problems of modern life, the hope being, of course, that in the future the engineer will take a more active part in formulating public policies in those fields with which he is professionally concerned.

3. Offering an opportunity for the student to analyze data and to prepare and present papers.

4. Of introducing the student to the engineering library, its facilities and its use.

INCREASING THE CURRICULUM

By JOHN YOUNGER

Professor of Industrial Engineering, Ohio State University, Columbus, Ohio

In all the discussion on the merits of a five-year or even a six-year curriculum for students of engineering, I have seen little attention paid to the after career of the graduate. Too much attention has been paid to what is happening or should happen during his scholastic years. It would seem as if effort is being concentrated on giving the student everything he needs during his years of university life and leaving nothing for him to study when his degree has been granted.

Let us examine what happens to our students after graduation with the Bachelor's degree. In most cases they serve a rigid apprenticeship for two or three years in an after education largely devoted, of course, to the policies, or products or construction processes of the particular firm with which they are connected.

Very often this practical work is supplemented by a course in what might be termed academic subjects, sometimes taught in the company itself, sometimes taught as post-graduate courses by an outside educational body.

We thus see at once that our students are not four-year students but are actually six- or seven-year students. True they are paid for the last two or three years, but this does not detract from the fact that they are receiving a supplemental education.

These students are 23 years old on the average when they receive their university degree; they are 25 or 26 years old when they have received their industrial education. They are 26 before they can settle down and say that they have satisfactorily completed their probationary period.

Surely this is ample enough education and surely this is late enough, if not indeed too late, for our engineers to begin their life career. An extra year or two would bring this age of starting to 27 years of age, far too late in life.

True the above industrial education is not broad or cultural in the accepted sense, but it is a question in my mind as to which should come first—engineering or so-called culture. It would seem with our young men entering life at a time when the forty-hour week is all that is necessary for work that the increased availability for leisure will lead to its use to study the cultural arts. We should remember very clearly that we cannot seek to complete a young man's education in our university. All we can hope to do is to give him good foundations on which he can build the rest of his life.

UNDERGRADUATE RESEARCH IN ENGINEERING *

By R. C. ERNST

Professor, Chemical Engineering,
Speed Scientific School, University of Louisville

The increased emphasis on research in American universities can be attributed to two developments. First in importance is the growth and extension of the educational system and the corresponding rise in prominence of the graduate school. With this movement came research as an integral part of advanced training. Second, the demands of a new industrial and economic era have promoted research in the various industrial fields. As a necessary adjunct pure and applied, and even coöperative, research in various forms has been extensively undertaken in the universities of the country.

Undergraduate research is the most direct expression of that trend in education and has been in many cases an attempt to derive the benefits that have been apparent in graduate research.

Research training is one of the traditional functions of the graduate school. The achievements in the pure and applied field justify its continuance. It has a function in training for similar work in the academic as well as the industrial field. It has resulted in the establishment of certain standards for academic advancement, and its achievements have resulted in even monetary gain both to the university and to the individual.

Undergraduate research, on the other hand, does not have the same traditional function in training, and the fact that it does not have great productivity, in the form of publishable or usable material, likewise eliminates it as having any great economic value. It can justify itself if it has an objective within the scope of undergraduate aims and activities. If research has a method, if it is functional and contributes to the general engineering education, it is justified.

Undergraduate research has for its function the teaching of a method and does not have the necessity of being productive or successful any more than any other curricular subject. If this premise be true, and since we are not training all students for research activities, the question of who shall be qualified to do undergradu-

* Presented at the Spring Meeting of the Kentucky Section held at the University of Louisville, April 19, 1934.

ate research is at once answered. It shall not be for any select group, but shall be for all students.

Research should have four distinct and relatively equally important stages. These are: the informative or reading stage; the planning or the theoretical consideration stage; the experimental stage; and the summary or conclusions stage. If each of these four stages contributes to the development of the student something that is not found to the same extent in our other courses, then we have justified this activity.

The initiating responsibility of research lies with the director. His function shall be to select a problem that will have reasonable possibility of success, and that will be consistent with the aptitude, the maturity, and the past achievements of the student. The problem should be of mutual interest to the director and the student. It should be difficult enough to demand the best efforts of the student, and a challenge to his ability. Past experiences in the course work have classified him as to ability and have established his reactions to various types of theoretical and experimental work. These should not be neglected in the selection of the type of problem he is assigned. The method in developing the problem is the same for all students, the variation will come in the intensity with which it is applied.

The primary function of the reading, or library work, is to familiarize the student with the past and present status of the problem, to ascertain whether the work has been already accomplished, to show the trend of experimentation in that field, and to know the methods and the technic developed by other workers. Until this time the student has carried on text book, magazine, and laboratory work of a standard character. He has learned the general method of various types and kinds of experimental work. In this reading he will observe the many variations in these same types of experimentation.

The reading in the abstract, technical, and trade journals, as well as reference books, has many advantages beyond the accumulation of facts and data to be used as the basis for future experimentation. One of the problems of engineering education is the inability of our students to read extensively, as an aid to intensive study. The advantages of a familiarity with a foreign language are all too obvious as the reading proceeds, and as the student obtains an appreciation of the achievements of the experimenters in other countries. A new phase in his education is awakened as the questions of patent and copyright possibilities are presented.

After any period of academic training, the young engineer who does not read can not hope to rise in his profession. This phase of the research offers the opportunity of introduction to the litera-

ture of the profession, going beyond the horizon of the text book, the handbook, and the established professional journal. It gives the engineering student training in the use of the literature in an advantageous and enlightened manner. It also serves to make him conversant in the general field of engineering and to make him a better informed man.

The completion of the reading, which should be intensive as well as extensive, should indicate what has been accomplished. It should bring a realization of the magnitude of the undertaking and should show the method, the technic, and the trend of the experimentation in that field. In some cases, it will point out the futility of, or the fallacy in, the problem. It may in some future years save months of futile experimentation. The preparation of the bibliography has a distinctive training that is not found in other courses in the curriculum.

The second phase in the research is the planning. This involves the theoretical considerations. The greatest weakness of the research man in the experimental field is the desire to do experimental work. In many cases much of the needless, wasteful, and worthless experimental work could be avoided.

The ablest research students are those who can plan; who can, from the basic principles and the specialized knowledge at their disposal, prove or disprove the validity of their thesis in order to justify performing the experimental work. What greater principle can be taught than that of justifying the project, the installation, or the research? Some principles of the physical sciences are involved in the validity of the project. The realization of these principles is imperative.

The experimenter here, for the first time, can draw on his own resources in working out on paper the major aspects of the problem. In our own laboratories we have considered making it a definite rule that the undergraduate shall complete his library work, write up the introduction, the historical, and the theoretical consideration before attempting any experimental work at all.

The literature of the past and the industrial blunders of today indicate the lack of a comprehensive appreciation of the magnitude of the projects, as well as the violation of some demonstrated basic principle, perhaps thoroughly understood, but poorly applied.

The economics of the problem, the physical hindrance, the proper sequence and coördination with other accepted ideas and practices of the day, can be demonstrated without experimental work, and can be done on paper. Because an idea is a good one, or that it works, does not necessitate future consideration if the economic structure under which it is developed does not coördinate with its practicability.

There is no doubt that these two phases of the research are as vital and important in the training of the individual as they are in the necessity of their observance if there is to be any hope for their productivity in the experimental work.

The director at this stage can be of infinite assistance if he will insist on a thorough theoretical attack of the problem. This will result in the student's doing additional reading in his own and related fields, from which he will draw many conclusions, and reduce not only the time but the cost of the experimental work to follow.

Even as the reading phase of the research has informed the experimenter what has already been accomplished, so the planning phase will establish, at least theoretically the validity of the problem. If the experimenter is unwilling to go through these stages, the chances for success are considerably decreased, and the problem will not be the product of research, but the product of an advanced laboratory technician.

The experimental stage involves the building and testing of the equipment and the accumulation of data. The individual has here the opportunity for demonstrating creative ability, mechanical aptitude, and initiative. The opportunity for using the laboratory technic is here at its height. But again the laboratory conditions are different. The initiative has passed entirely to the student. Here the student can be observed under his own motive power. Has he become one who can follow precise instructions on the well oiled machine with calibrated instruments, or can he adjust himself to the simple and even crude experimental apparatus and still obtain relatively reliable results? Will he be able to accept the petty hindrances of his problem? The student will demonstrate more of his latent ability in this than in any other laboratory. Here better than in any other place he shows how he will react on the future job. Here one comes to know the man.

The responsibility of the director in the experimental stage is apparent. It is his obligation to be an adviser that encourages without doing the work; to approve though not initiate the changes to be made; to encourage when all seems wrong; to advise further reading and consideration of the theoretical as a possible solution to the difficulties encountered. Above all, the man should be allowed to develop himself. On the other hand when the difficulties become unsurmountable the director should be willing and able to make the temporary adjustment. Here the undergraduate and the graduate methods differ. The research should be carefully supervised, and independent research should be expected only to the limit of the then developed power of the individual. To refuse

honest, necessary aid is a reflection on the judgment of the director as much as on the ability of the student. Let us be judicious on this point, remembering that we are teaching a method to our undergraduates. We are in this phase drawing on his power to do independent, experimental work. There are many phases to be developed, it may be technic, it may be initiative, it may be creative ability; but let us be satisfied if he can develop one of these to its fullest extent, and strengthen the others.

In the accumulation of data we can see whether the student has adsorbed our favorite laboratory technic and methods, but let us, above all, be sure that he has learned to make a permanent and reliable record. Let us see whether he has learned to distinguish between important and unimportant information. Let us see that he does not anticipate results at the expense of reliability. Here again we can observe his reaction when things go wrong, and his behavior under endless repetition.

Through these three stages one can get an estimate of the characteristics of the man, and can so direct him as to correlate certain deficiencies. The next stage is the one in which men may have the greatest training, but give the poorest results. Our education has resulted in the perfection of the laboratory method, but our men either cannot or do not in their theses draw adequate or correct conclusions.

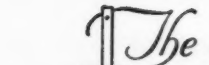
Our greatest weakness is in obtaining too much experimental data; important though it is, it is the lesser part of our method. Any technician can take the data in most cases. The real problems in research are the reading, the planning, and the conclusions.

The evidence in the case is conclusive. At frequent intervals an experimenter will assemble the published results of others and with or without any additional experimental evidence propose an outstanding theory, or draw an important far-reaching conclusion. Of what value are the well-planned and laboriously obtained results if they can not be correlated, and a useful conclusion drawn. Negative as well as positive results are contributory to progress if the reasons can be assigned for them. The eagerness to get into print or to complete work is often the reason for the poor and inconclusive work.

The real problem in research is to be able to evaluate what others have done, plan our own experimentations, perform the work, and make reasonable conclusions. These are briefly the four stages in the research method. The objective of each has been outlined. The obligations of the director and the benefits to the experimenter have been stated.

The many aspects of research have been discussed in academic circles for years. The advantages and disadvantages are apparent, but let us remember that undergraduate research has a method worthy of our consideration.

The undergraduate research here is not justified by any advantage to be derived by the faculty. These are other aspects beyond the scope of this paper.



The T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE DIVISION OF ENGINEERING DRAWING

FREDERIC G. HIGBEE, EDITOR

Whenever and wherever the Division of Engineering Drawing meets there is sure to be in attendance a large representation of those who are devoting themselves to the teaching of Engineering Drawing and allied subjects. The meetings of this group have always been important, worthwhile, and instructive. The Cornell meeting in June promises to set even a higher standard for this group and every teacher of drawing should plan to attend.

At a number of meetings of this kind, there has been sounded a note which has given those in charge of drawing courses considerable concern, and so many have commented on this element of the problem of teaching drawing that it seems worthy of more than passing notice.

Briefly the comment is to the effect that after the course in beginning drawing is over, engineering students are not always required to follow the high standards of draftsmanship insisted upon by their drawing teachers. The results of such a debasing of quality is thoroughly unhealthy and imposes upon drawing departments an unnecessary and obvious hardship.

Certainly no argument needs to be advanced for a high standard in drawing. Nor is it necessary to discuss the deteriorating effect of allowing students to use poor English in their written and oral work and compare such a situation with a like one in drawing. Nevertheless, too many drawing teachers report that their efforts in developing good draftsmen are neutralized by the indifferent and passive attitude on the part of other departments toward drawing of high quality. Such a condition does not indicate sound educational procedure.

Drawing departments deserve and need the coöperation and the sustained interest of all departments of the college in developing engineers who are able to make good drawings. It is an accepted fact that students will do, on the whole, no better work than required. By insisting upon the high quality of drawing of which students are capable, advanced departments will be doing both the student and the drawing department a real service.

COLLEGE NOTES

University of Illinois.—The Department of Mining Engineering was re-established by the Board of Trustees in 1909, and for 25 years it has been in continuous operation. On April 11, 1934, the Board changed the name to "The Department of Mining and Metallurgical Engineering," because this year, for the first time in the history of the University, a curriculum in Metallurgical Engineering is being offered. It is now in operation for freshman and sophomore students, will be opened to juniors in 1934–35, and will be in full effect in 1935–36.

Metallurgical instruction at Illinois is not new, for there has been a metallurgical option in the Mining Engineering curriculum for nearly 20 years. With the complete expansion of this option into a full curriculum in Metallurgical Engineering, students from the State of Illinois are no longer compelled to go to a university in some other state for instruction in metallurgical engineering.

Massachusetts Institute of Technology.—Changes were made in the course in mechanical engineering whereby the fourth year is divided into six optional fields of study and will go into effect next fall. The new curriculum offers options in automotive, power, refrigeration and air conditioning, production, and textile engineering, as well as a general option for students who desire a broad training and for those who expect to engage in graduate study. All the options include a certain amount of elective time, thus making it possible to select courses of special interest. The new optional system was adopted in recognition of the growing scope and complexity of mechanical engineering, and the difficulty of covering adequately its many important fields in the normal four year course.

The General Option presents a program well balanced between mechanics, thermodynamics, and design. It is especially arranged for students desiring a general training in mechanical engineering, and for those expecting to engage in graduate study.

The Automotive Option, as the name indicates, concentrates in automotive engineering and production, with emphasis on either engine or chassis design. The Power Option specializes in the applicatory phases of thermodynamics relating to power generation, and the design of the necessary equipment.

The Refrigeration and Air Conditioning Option concentrates in the technical phases of heat engineering as applied to these increasingly important subjects. The Production Option is intended

for those who are primarily interested in the problems of production and machinery, with emphasis on materials and processes.

The Textile Option is designed as preparation for a fifth or graduate year in textile technology. The operational and management phases of textile engineering are obtained through the General Option or the Production Option, with textile electives.

Professors Richard H. Smith and J. Van H. Whipple of the Department of Aeronautical Engineering have recently completed a preliminary report on air force measurements on bodies moving through still air. Their apparatus was set up in the steam laboratory where runs were made, usually at night because then the air was much stiller. It was important that the air be perfectly quiet since turbulence alters the sensitive flow around a moving body as the critical bluntness of a body at which the flow breaks away from the surface, is approached. In such critical cases the measurement of the pressural reactions on a body in a wind tunnel are either of doubtful value or are distinctly deceptive and cannot be safely used as the basis for the study of important dependent phenomena such as spinning or lateral control at the stalling point.

The method for the preliminary tests was to move the models through the still air of the large room in a straight line with as nearly a uniform velocity as possible and to measure the speed, the model lift, and the drag simultaneously. The models were mounted on a suitable carriage running on two long and very taut wires, slightly inclined. The carriage was then launched at nearly terminal velocity, allowed to coast down the wires, and then brought to rest by a retarding gear. The absolute speed was measured with an electric tape chronograph, while the lift and drag forces were recorded as continuous records on a smoked glass chart borne and rotated by the carriage. The drag mechanism was in dynamic balance and quite independent of the lift mechanism. Both were oriented accurately to each other and to the wires.

Professor Walter C. Schumb of the Department of Chemistry has been studying the influence of the electrodeless discharge upon chemical changes occurring in gases at low pressures; in particular, the syntheses of ammonia and of carbon dioxide. Further light is being thrown upon the causes of the known lack of applicability of the so-called law of "mass action" to reactions in electrical discharges.

In coöperation with Professor Guillemin of the Department of Physics a study of the effect upon chemical changes of supersonic vibrations is under way, and a magnetostriction apparatus has been assembled to serve as the source of the vibrational energy.

The thermal decomposition of thionyl chloride is being investigated quantitatively at different temperatures. From the results

to be obtained in this work it is anticipated that an improved method of synthesis of this valuable reagent may be developed.

With the aid of Professor Arthur C. Hardy's recording color analyzer, and the new polarimeter of the Research Laboratory of Organic Chemistry, a comparative series of measurements of the absorption and of the rotation shown by optically active compounds of the rare earth and other elements is under way. The data obtained are being applied to a further study of the Cotton effect.

Dr. Ralph C. Young is continuing his study of the lower valences shown by the elements of Group IVa of the Periodic Table, with especial attention to the element thorium, which up to the present has successfully resisted all attempts to induce it to assume a valence less than four. The elucidation of the striking anomaly shown by thorium in this respect, in comparison with the elements zirconium and titanium, is the primary objective in this work.

SECTIONS AND BRANCHES

Arkansas-Oklahoma Section.—The opening session of the fourth annual meeting was a dinner held at the College Shop which was attended by 81 members and guests. President R. L. Flanders presided at this meeting.

The President appointed two committees as follows: Nominating Committee: Professor R. G. Saxton, Chairman, Professor W. R. Spencer and Professor F. G. Tappan. Committee on Constitution and By-laws: Professor W. B. Stelzner, Chairman, Professor A. Naeter and Professor C. L. Farrar.

Dean W. N. Gladson of University of Arkansas, being introduced by the President, presented a paper on "The Engineering Curriculum." It was formally discussed by Professor F. G. Tappan of the University of Oklahoma and Professor E. C. Baker of Oklahoma A. and M. College. Informal discussions were given by Dean J. H. Felgar of O. U. and Professor V. W. Young of Oklahoma A. and M.

At the conclusion of the first paper the President introduced Professor J. R. Nielsen of University of Oklahoma who presented an interesting paper on the subject "Engineering Education in Scandinavia." It was discussed briefly by Professors H. M. Hosford, C. L. Nickolls, A. Naeter, G. A. Hale, and Dean Felgar.

Professor L. K. Covelle of Oklahoma A. and M. College presented a paper entitled "Vocational Education in the Oil Fields and Its Relation to Formal Engineering Education." It was discussed by Professor R. G. Paddock of A. U., Dean J. H. Felgar of O. U., Professor V. L. Maleev of A. and M., Dean Gladson, Professor Stelzner and Mr. Whiteside.

The following were elected for 1934–35: President, W. B. Stelzner; First Vice-President, C. L. Farrar; Second Vice-President, O. M. Smith; Secretary-Treasurer, A. S. Brown.

The invitation to hold the next meeting at the University of Arkansas was accepted.

C. M. LEONARD,
Secretary-Treasurer.

Note: The following petition has been granted. Editor.

The Technical Conference, composed of faculty members in Engineering, Mathematics and Physics at Bucknell University, organized in September, 1925, desires to become the **Bucknell Branch** of the S. P. E. E.

We petition the Executive Committee for recognition as a branch and agree to operate in conformity with the Constitution and By-Laws of the Society.

F. E. BURPEE, *President,*
R. A. GARDNER, *Secretary.*

At the last meeting of the **Lafayette College Branch** of the S. P. E. E., on April 26, 1934, the following officers were elected for the ensuing year: Professor William S. Lohr, Chairman; Professor Paul B. Eaton, Vice-Chairman; Professor Frederick W. Slantz, Secretary-Treasurer.

EDWARD H. ROCKWELL,
Secretary.

The 1934 Spring Meeting of the **Middle Atlantic Section** of the Society was held at Haverford College, on May 5.

In the morning many of the members went to the plants of Leeds and Northrup Company in Philadelphia or the Autocar Company at Ardmore.

As the business session opened in the Haverford Union, President W. W. Comfort welcomed the "spring folic," telling of the undergraduate work and system of admission at Haverford. President Morland King was in the chair. Professor Timby of Princeton spoke of the Conferences for teachers, dealing with many subjects and methods of teaching, research and administration, to be held just preceding the Annual Meeting at Ithaca, June 19–21, 1934.

"The Economic Sequence in the Civil Engineering Curriculum" at Columbia University was the title of an interesting paper by Professor J. K. Finch. Mr. Roy V. Wright, Managing Editor of the "Railway Age," and past-president of the A. S. M. E., addressed the meeting on "Engineers and Citizenship."

There was much discussion aroused by these papers, showing the interest within the group in the economic, governmental, and even social side of the embryo engineer's training.

Following dinner, during which we were entertained by harmonica music played by John S. Pugliese, an undergraduate of Haverford, Mr. Morris E. Leeds, president of Leeds and Northrup Company, president of the Corporation of Haverford College, and recent vice-chairman of the Industrial Advisory Board in Washington, spoke on "The Significance of the National Industrial Recovery Act." Following a spirited discussion, in which Mr. Leeds was called on to answer many questions, the meeting adjourned to meet at Stevens Institute in the fall.

CHARLES G. THATCHER, *Secretary.*

The third regular meeting of the **Minnesota Section** for the academic year 1933–34 was held April 23, 1934, and was given over to a discussion of economic conditions in the Northwest.

The principal speakers of the evening were Professor F. B. Garver of the Economics Department, and Professor L. H. Reyerson of the Chemistry Department, both of the University of Minnesota. Professor Garver discussed the trend of industrial development in the Northwest. He indicated that relative to other parts of the country agricultural development was increasing, manufacturing industries decreasing. Professor Reyerson indicated the possibilities of the development of this region by the aid of research in the use of raw materials which are locally available. The evaluation of local raw materials will provide a stable development to this section of the country.

The following officers were elected for the academic year 1934–1935: President, Professor H. H. Dalaker; Secretary-Treasurer, Professor A. R. Ford; Chairman, Program Committee, Professor G. H. Montillon. Professors H. B. Roe and H. A. Doeringsfeld were appointed to the Program Committee.

LORENZ G. STRAUB,
Secretary.

The Fourth Annual Meeting of the **Texas Section** was held at the Rice Institute, Houston, Texas, April 19 and 20, 1934, with T. U. Taylor, President, presiding.

C. W. Crawford of Texas A. and M. presented a paper on "Faculty Research to Improve Teaching." L. B. Ryon of Rice discussed the paper.

E. C. H. Bantel of Texas University read the paper by E. P. Schoch on "Research by Faculty Members." F. E. Giesecke of Texas A. and M. discussed the subject.

W. L. Porter of Texas A. and M. presented the subject "College Algebra for Freshmen Students Based on One and One-half High School Entrance Units." Hugh Porter of Texas C. A. and I. and H. E. Bray of Rice discussed the subject. R. D. Landon of S. M. U. read a discussion written by E. D. Mouzon, Jr., of S. M. U. At Dean Taylor's request H. E. Degler of Texas University read an encouraging message to the Texas Section on the general problem of adjusting the engineering curriculum to the actual preparation of engineering students in mathematics, written by W. E. Wickenden, President of the Society. Dean Taylor, J. A. Correll of Texas University, and N. F. Rode of Texas A. and M. gave additional discussion on the subject from the floor.

Dean Taylor reported that the engineering faculties of the two engineering schools in West Texas had been approached by mem-

bers of engineering faculties of schools in New Mexico and Arizona inviting them to join in forming a section of the S. P. E. E. in that area, and that the engineering faculty of Texas Tech had voted unanimously to stay in the Texas Section—and in addition Texas Tech had repeated their invitation for the Texas Section to meet there in 1935.

H. E. Degler made a motion that the Texas Section accept the invitation of Texas Tech; Dean Bolton now in the chair, Dean Taylor seconded the motion, which carried unanimously.

Dean Taylor appointed the following committee to nominate officers for next year: F. C. Bolton, E. H. Flath, J. A. Focht, R. L. Peurifoy, J. H. Pound, W. E. Street. He also appointed the following committee on resolutions: O. V. Adams, J. A. Correll, H. F. Huffman, Hugh Porter, J. J. Richey.

At the banquet, Dean H. B. Weiser of Rice gave the address of welcome, E. C. H. Bantel responded for the Texas Section. Clarence Wharton gave an address on "Historical Landmarks in and near Houston." Dean Taylor gave the President's address. His subject was "Pioneer Engineering in Texas."

At the next meeting, O. V. Adams of Texas Tech gave a paper on "The Place of Business Management in the Engineering Curriculum." R. P. Ward of Texas A. and M., E. C. H. Bantel of Texas University, and E. H. Flath discussed the paper.

Discussions of laboratory reports, their form and content were given by: L. V. Uhrig of Rice, N. F. Rode of Texas A. and M., and R. L. Peurifoy of T. C. A. and I.

Dean Bolton made the following report of the nominating committee: President, E. H. Flath, S. M. U.; Vice-President and Chairman of the Program Committee, O. V. Adams, Texas Tech; Secretary-Treasurer, W. E. Street, Texas Tech; Executive Committe (3-year term ending 1937): H. C. Doremus, John Tarleton; J. W. Kidd, School of Mines; M. C. Stone, North Texas A. C.

The report of the Committee on Resolutions was accepted:

WHEREAS, Dr. W. E. Wickenden, President of the Society for the Promotion of Engineering Education, who was invited to attend this meeting of the Texas Section, finding it impossible to be present, has evidenced his interest in the problems we have taken up for discussion by writing for presentation at our meeting a paper dealing with the problem of accommodating our college instruction to the inferior preparation of entering students, and

WHERAS, the thoughts presented in this paper are of special value by reason of Dr. Wickenden's well known and extended study of the general field of engineering education and have contributed some of the most sentient and pertient comments presented at this meeting, and

WHEREAS, that portion of Dr. Wickenden's discussion concerning the value and importance of training in high school mathematics should be of peculiar interest to the teachers and administrators in the secondary schools of Texas,

Be it resolved, that the Texas Section formally express to Dr. Wickenden its appreciation of his interest and counsel, and

Be it resolved, that the present secretary of the Section be instructed to send, with Dr. Wickenden's consent, a copy of this paper to the secretary of the Texas State Teachers Association for such publicity as may be found desirable, and

Be it resolved, that a copy of Dr. Wickenden's paper be sent to the secretary of the Texas Section of the Mathematical Association of America for such attention at the meeting at College Station on May 5 as may be found suitable, and

Be it further resolved, that a copy of this paper be sent, with the author's consent, to the editor of the JOURNAL OF ENGINEERING EDUCATION, with the suggestion that it be published in that journal.

THAT WHEREAS, the Texas Section, Society for the Promotion of Engineering Education, is vitally interested in the quality of work done in the secondary schools of the state, and

WHEREAS, the Texas State Board of Education has passed regulations requiring that high school teachers shall have a major or a minor in the subjects which they teach,

Therefore be it resolved, by the Texas Section, S. P. E. E., that we endorse said action by the Texas State Board of Education and pledge ourselves to support such action in every possible way, and that a copy of this resolution be sent to the Secretary of the State Board of Education.

WHEREAS, the Texas Section, S. P. E. E., is vitally interested in the quality of work done in mathematics in the secondary schools, and

WHEREAS, said Section desires to make a specific contribution to this end,

Therefore be it resolved, that it is the sense of this meeting that the Texas Section, S. P. E. E., should collect data on the mathematics records of engineering students in engineering colleges, and send such data to the authorities in charge of the respective high schools in the state.

WHEREAS, a movement has been started for the formation of an Arizona-New Mexico Section of S. P. E. E., and

WHEREAS, Texas Technological College has been invited to join the organization of this new section, and

WHEREAS, the engineering faculty of Texas Technological College have unanimously refused to sever their connection with the Texas Section,

Now therefore be it resolved, that we commend them for their action in this matter and express our appreciation of their demonstrations of faithfulness and loyalty to the objectives of the Texas Section of S. P. E. E. in our common effort to improve the teaching of engineering in the state of Texas.

Be it further resolved, that a copy of this resolution be sent to the administrative authorities of Texas Technological College and to the Chamber of Commerce of Lubbock, Texas.

WHEREAS, the members of the Texas Section of S. P. E. E. have enjoyed the hospitality of Rice Institute, and

WHEREAS, the success of this meeting has been greatly enhanced by the courtesy and efficiency shown by the local members in making the preparations for the meeting,

Now therefore be it resolved, that we express our appreciation to the officials of Rice Institute for the privilege of holding our meeting on this Campus, and to the engineering faculty of Rice Institute for their painstaking

efforts for our entertainment and pleasure during our stay; and to the ladies of the Institute for the courtesies extended to the visiting ladies.

The incoming President of the Texas Section of the S. P. E. E. was authorized to appoint a committee to study a plan for improving the quantity and quality of high school entrance units presented by freshmen; to appoint delegates to attend section meetings of the Texas State Teachers Association dealing with subjects vital to engineers; to appoint a committee to prepare plans and send an invitation to the President of S. P. E. E. to hold the 1936 national meeting in Texas during the Texas Centennial.

Group Meetings—held simultaneously.

Civil and Mechanical Engineering—H. E. Degler of Texas University, chairman.

L. E. Grinter of Texas A. and M. presented a talk on "New Methods of Stress Determination and their Introduction to the Student." A. H. Burr of Rice discussed the subject.

B. E. Short of Texas University presented a talk on "The Teaching of the Mechanics of Fluids." Following informal discussion the meeting adjourned.

Electrical Engineering—M. C. Hughes of Texas A. and M., chairman.

M. C. Hughes presented a paper on "The Relation of the First Two Years of the Electrical Engineering Course to the Last Two." N. F. Rode of Texas A. and M., J. A. Correll of Texas University, J. W. Ramsay of Texas University, E. H. Flath of S. M. U., and H. C. Dillingham of Texas A. and M. entered into informal discussion of the subject.

Engineering Drawing—C. E. Rowe of Texas University, chairman.

The following papers were presented:

"Importance of Descriptive Geometry in the Engineering Curriculum," by F. E. Giesecke of Texas A. and M.

"The Teaching of Engineering Drawing Through a Combination of Theory and Practice Classes," by W. E. Street of Texas Tech.

"Testing in Engineering Drawing," by H. C. Spencer of Texas A. and M.

"Teaching Aids in Engineering Drawing," by J. M. Miller of Rice Institute.

"Grading in Engineering Drawing," by W. H. McNeill of Texas University.

Discussion of the papers was led by E. L. Williams of Texas A. and M.

L. Vernon Uhrig,
Secretary.

My good friend Dean Taylor is one of the unfailing beacon lights of engineering education. Other deans may come and go, or even descend to the ignominy of becoming college presidents, but Dean Taylor shines on forever. As a penance for having to decline his seductive invitations to attend your spring meeting in person, I have agreed to write a few brief observations on the problem of adjusting the engineering curriculum to the actual preparation of engineering students in mathematics.

This theme is one of our hardy perennials. Ever since there were engineers or any one thought of educating them it has been a problem. Formal education for engineers was born of a desire to get away from the rule of thumb of self-trained men, each following the guidance of his own experience, and attain unto a dependable science. This fight is not yet wholly won. We still hear graduates boast of having never used calculus since leaving college and suggest its deletion from the course of study. I have no doubt that a fairly effective sort of engineering education could be given with no mathematics other than arithmetic and simple algebra. The pyramids of Egypt were built without derricks, I believe, but it took a long time in an age prodigal of labor.

At the risk of being dogmatic, I am going to assert that the key to economy of time and effort in an engineer's education is superior training in mathematics. However, our engineering colleges recognize that they must accept the actual product of the accredited high schools and that this product can be only slightly sifted and adjusted to our special requirements. We have neither the right nor the power to dictate terms, yet we are justified, I believe, in getting the best terms with the high schools which can be had through mutual understanding and agreement. In judging the adequacy of a student's preparation, mathematics is the crux of the matter, and we may do well to concentrate on it. After all, we lean but lightly on preparatory education in other sciences. What physics, chemistry or biology a student may learn in high school is not of vital moment to us. Mathematics, on the other hand is foundation work on which we have to build directly. It touches the engineer's tools of work and habits of thought in an essential way. The engineer is almost the only man who deals with the practical details of life in quantitative relations beyond the scope of arithmetic. Furthermore he is almost alone in his concern with functional relations rather than mere amounts of things or money. High school officials and teachers who think in terms of adjustment to every-day life situations are inclined to consider the engineer as a specialist, too scarce to bother over, while teachers of elementary mathematics are little aware of the engineer's mathematical needs and habits.

Where we find mathematics holding its own in the high school curriculum it is more often as a traditional carry-over from the days of formal discipline than because of any real appreciation of its functional values in the world of common activities. In a word, if we wish to save any mathematics of rigorous quality in secondary education, we may need to educate the educators. Especially, we shall need to strengthen the motivation of high-school mathematics, which now seems to be at its weakest point.

What we have at stake is not merely the student's technical preparation for certain higher studies, but the selective results of his training as well. In nearly all the studies of the predictive value of school records for probable success in an engineering college, mathematics ranks first. It is in mathematics that the student first and often only finds himself in a realm where methods are more important than facts and where the line can be sharply drawn between actual mastery and mere getting-by. Lincoln, we recall, set himself to the study of geometry in order to grasp the full meaning of the word "demonstrate." As our school curricula are now arranged, mathematics is almost the only subject of cumulative study, where a deficiency of mastery in any one term remains to plague the student in the next, and where mere memorizing and verbal plausibility are certain to break down sooner or later. It is these intellectual and moral qualities, quite as much as pure content, which give mathematics its high value as a selective filter for engineering ability in the American high school, even though the subject is often poorly taught.

In our efforts to protect the place of mathematics in high-school education, our best allies may and should be the high-school mathematics teachers themselves. Many of these potential allies are getting faint hearted for lack of encouragement and appreciation. The officers of our engineering colleges ought to discover which teachers are doing consistently excellent work and see that they are commended, both directly and to their superiors. They will then fight our battle for us.

When we have done all that we can to hold or gain ground for mathematical preparation, we are still fairly bound to take the product of the high school as we find it. Some of it, however, we can only accept provisionally, if at all. From our experience with eliminations it is clear that we are getting very few good risks from the lowest third of many high-school classes. No matter where we draw the line, we must expect to teach a lot of quite elementary mathematics ourselves. When I visited the engineering schools of Belgium a few years ago a wise professor who was guiding my initiation made this observation: "In Belgium, every primary school is trying to be a secondary school, and every secondary

school trying to be a university; the university, therefore, is compelled to become a primary school." The same is true in America, perhaps even in Texas. The whole subject of mathematics needs review and up-grading in the freshman year and time so spent is more than recovered through rapid progress in more advanced work. Mastery, which is what we are seeking rather than mere acquaintance, comes only through repeated relearning.

The student who enters college with less than normal mathematical preparation may find it a blessing in disguise, if the result is that he learns his fundamentals under a skilled college teacher in a class doing intensive work rather than under a make-shift teacher in a high school class of dilute ability and interest. What the student must discover and the high schools must learn is that there is a minimum level of mathematical preparation in which a student can hope to complete a satisfactory training in engineering in four normal college years. My personal observation leads me to set this minimum level at about 2½ units of preparation of not less than C plus grade. If the entering student offers less, but is otherwise well qualified, I believe we should accept him, but lengthen his course accordingly either by required summer work or by a five-year program.

At present it does not seem practicable to keep engineering education at the same formal level over the entire country. We cannot fulfill our educational mission in any Procrustean manner, like the schools of medicine under the vigilant eye of the American Medical Association. Certain minimum standards we should insist upon, but the actual condition is likely to remain that a few most favored institutions will reach a level at the granting of the bachelor's degree not far different from that which many excellent and highly useful institutions could reach only in five years. To strain after uniformity of standards would be artificial. To serve our regions on the level of the standards of popular intelligence and public education which surround us, is still good sound doctrine for engineering education.

W. E. WICKENDEN,
President, S. P. E. E.

BOOK REVIEWS

Fundamentals of Hydro- and Aero-Mechanics. PRANDTL AND TIEJENS (translated by DEN HARTOG). Published by McGraw-Hill Book Co. as an Engineering Societies Monograph.

This volume deals with the fundamentals of hydro- and aerostatics and dynamics in a manner very satisfactory to both the engineer and the physicist. There is a very definite correlation of theory and experimental results which was hailed by the engineering profession when the text was first published in German.

The text is not particularly suited to the average engineer due to the fact that a good portion of the proofs and mathematical reasoning are carried out by means of vector analysis. For this same reason, however, and also because of the rigorous proofs, the text would be ideally suited for a graduate course in hydrodynamics or aerodynamics such as is generally given by departments of physics. The text should also be useful to teachers of advanced mathematics courses to give an excellent slant on the practical uses of vector analysis and differential equations.

There is no discernible difference between the original German text and the American translation. Like the majority of the German books, there are no "problems."

The translation, in the reviewer's opinion, is one of the best translations of a German work that has been offered to the American engineering profession. (This is probably due to the fact that Dr. Den Hartog, who made the translation, is thoroughly familiar with the material that he was translating.)

HENRY PAVIAN.

Practical Forms in Exposition. HARLOW C. RICHARDSON, LUTHER N. BECKLUND, LEDRU O. GUTHRIE, AND CLIFFORD I. HAGA (of the University of Minnesota). $2.00, 6" × 9¼"; 416 pp. New York: The Macmillan Company.

If the authors of this book have made an error, it is one of being over-complete. It does not seem necessary that a book on expository writing should run to four hundred and sixteen pages, even one with rather complete illustrations. In attempting to be all things in matters of exposition, the Minnesota teachers have allowed too careful inclusion to take much of the edge off the purpose of the book. Any book, even a textbook, should have something inspiring about it, something in it to "startle and waylay."

Bulk can never be so convincing as clear-cut suggestiveness. The error is decidedly not one of omission.

Nevertheless, here is a book tumid with information. If you are responsible for the teaching of English to Engineers in your school and if you can be sure that your instructors will hold the students to the text, then order this rhetoric for next September. Your students will have between one set of covers "a manual designed to assist technical students with papers, letters, reports, and reading." And the book should be a genuine assistance. First, it is sanely put together. Part One comprises elementary forms, from which the student learns about the basic units of technical writing. In Part Two, the student receives instruction in the application of the elementary forms to new techniques. Advanced forms of technical exposition make up Part Three. Here the relationship is shown between the practice pieces the student has been working on and the forms used in actual technical reports. Second, the authors have included many illustrations of the proper way of keeping bibliographical cards, of the procedure in preparing a report, and of the use of graphs and charts. And third, "Practical Forms in Exposition" will do as a sort of ready-reference handbook. The proper salutations and complimentary closes for business correspondence are carefully put down, as are the proper methods of writing numbers, abbreviations, fractions, and footnotes. Besides, there is a very valuable portion which tells the student how to use the library. In the front of the book is a rather long though not definitive reading list. It is refreshing to note that technical students are urged to read outside their field requirements. The authors have recognized that the well-read engineer is the most valuable engineer, and not the least valuable facet of their book is the repeated admonishing of the student to read and know. "Practical Forms in Exposition" is a good book, one which should be valuable. And yet, such directions as "the report should be typed on strong white paper of good quality, $8\frac{1}{2} \times 11$, on one side of the leaf" and "It is obvious that it would be folly for a student to undertake a report about which he knows absolutely nothing" seem just a bit elementary to the student who is advanced enough to know that he is a technical student. To repeat, however, this is an excellent book for the student who must work largely by himself and for the instructor who wants a standard to which his class must conform.

JENNINGS HAMMER.